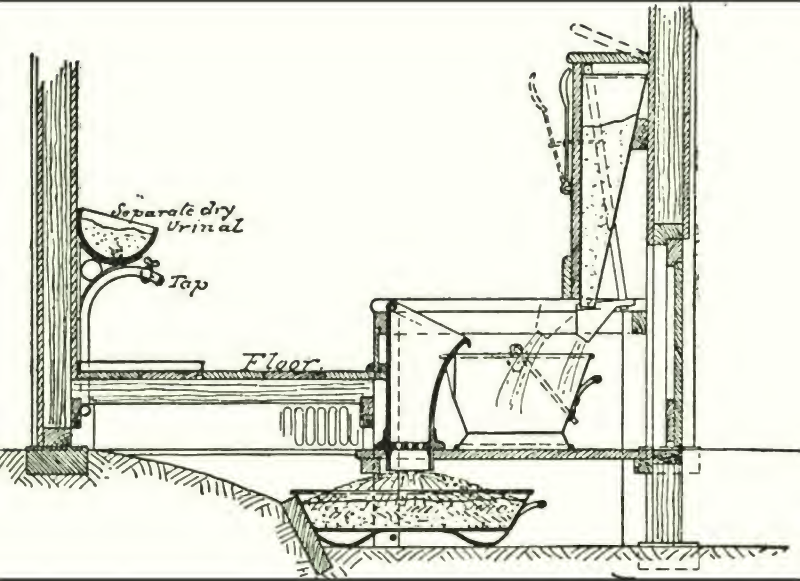

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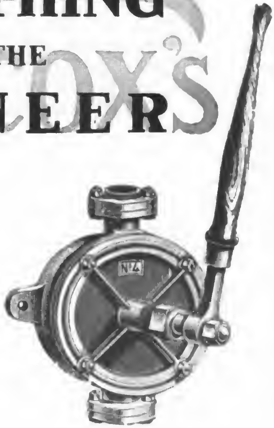

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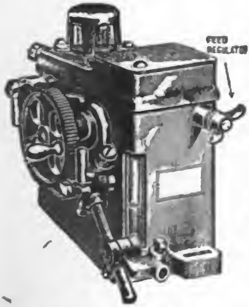

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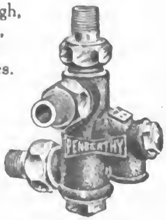

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DYES AND DYEING.

(*See also* STAINS AND STAINING.)

THE art of dyeing is so nearly allied to staining that some difficulty is found in making a dividing line for the two. Leather, for instance, is said to be stained, although an aniline dye may be used for it, while kid gloves are said to be dyed. Students of this subject should read up both Dyeing and Staining. It is of great importance that every article that is to be dyed (or stained) should be perfectly clean—chemically and mechanically clean. There must be no grease, no "dress" or other foreign substance in it; and, when clean, it should not be handled with the hands more than is necessary. Scouring with soap and water is a good cleaning process, but every particle of soap must be rinsed out afterwards. It is a good plan to pass the article through warm water before treating it with the alum or other preparation. When an article is dyed it is a good plan, when possible, to air it a little before rinsing and drying.

Cotton Dyeing.—Cotton, like all vegetable fibres, is easily injured by acids, consequently, neither mordants nor colours of a strongly acid character can be employed; otherwise the goods will be corroded, and the colours will fail to be duly absorbed. The solutions employed must be very feebly acid, neutral, or even alkaline. Another important feature is the temperature at which cotton is dyed. In the majority of cases it is worked in the cold, or at a "hand-heat," i.e. at about 90° to 100° F. (32° to 38° C.). It is most extensively dyed in the state of yarn, but a large quantity also after being woven. This especially relates to the mixed fabrics, known as Bradford goods, the warps of which are cotton, and the weft worsted. The perfection of cotton dyeing is to produce on these warps the same tone and depth of colour as are found on the worsted, so that the entire piece may appear even, and free from any checky character.

It will now be convenient to give a series of approved recipes for producing the principal colours upon cotton, selecting such as best illustrate the resources of the modern dyer, and having especial regard to aniline and its allied tinctorial substances.

Blacks.—(1) Fast. For 110 lb. cotton yarn or cotton wool.—8¾ lb. solid extract of logwood, 5 lb. 10 oz. catechu. Boil up together, boil the yarn in the decoction for 1 hour, steep in the cold liquid for 24 hours; raise to a boil again; lift, and air over night. Dissolve in sufficient fresh water 24⅓ oz. chromate of potash, and 24⅓ oz. blue vitriol, and work the cotton in this for ½ hour. Lift and drain. Dissolve 2¾ lb. soda ash in the cold logwood liquor. Heat to 139° F. (87° C.), re-enter the cotton, work 15 minutes, and rinse. This colour bears washing and milling, and does not smear whites.

(2) Aniline, for 100 lb.—Mix 6 lb. 9 oz. aniline oil with 8 lb. 12 oz. hydrochloric (muriatic) acid at 32° Tw. Let cool and add solution of 4 lb. 6 oz. chlorate of potash in 66 pints of water, and finally add 43¾ pints of a solution

of chloride of iron at 32° Tw. Steep the bleached yarn for 8 to 10 hours in the liquid, which must previously be diluted with water at about 100° F. (38° C.); take out and place it in a solution of soda at 23° Tw., to neutralise the excess of acid. Wash, and steep for ¼ hour in a beck made up with 66 pints water and 7 oz. chromate of potash at about 112° F. (45° C.). This treatment prevents the dye from subsequently turning green. Wash, and pass the yarn through a mixture of 17¼ oz. emulsive oil (such as is used by Turkey-red dyers), 2 lb. 3 oz. potash, and 66 pints water. Dry at once.

(3) Aniline, for cotton yarns (De Vinant's).—The cotton yarn, well boiled out, receives 7 turns in a beck, made up with 7 oz. sulphate copper for every 2 lb. 3 oz. yarn, dissolved in water slightly soured with muriatic acid; it is then well wrung out. It next requires 5 turns in water at 122° F. (50° C.) containing 1¾ oz. sulphide of sodium per 35 fl. oz. liquid, and is again rinsed. It then has 7 turns in a beck of 17½ pints water, 6¼ oz. chlorate of potash, and 5⅞ oz. sal-ammoniac, all dissolved by heat, and mixed with 16½ oz. muriate of aniline. It is then stretched out very regularly in a drying-room, and kept for 48 hours at 76° F. (25° C.). Lastly, it receives 4 turns in water containing 15¼ gr. bichromate of potash per 1¾ pint at 86° F. (30° C.), and is then well washed, and dried. If the black has a foxy tone, take through 87 qt. cold water, to which has been added 35 fl. oz. bleaching-liquor at 8° Tw. Without great care, the blacks produced by this process are cloudy.

(4) Aniline with vanadium (Pinckney's).—Take 150 oz. muriate of aniline, ⅛ oz. salt of vanadium, 20 oz. chloride of nickel, 100 oz. chlorate of potash, 2500 oz. water. The yarns are steeped in a mixture of these substances, and dyed either hot or cold. In subsequent practice, the chloride of nickel has been found unnecessary, and the salt of vanadium admits of a great reduction in quantity.

(5) Aniline.—Scour well, and for each 1 lb. cotton yarn, take 3½ oz. sulphate of copper, dissolved in water made very feebly acid with spirits of salts (muriatic acid). Give 7 turns, and wring well. Dissolve ½ lb. hydrosulphide of soda per gal. of water at 123° F. (49° C.), give 5 turns, and wash well. Dye cold in 3 oz. chlorate of potash, 3 oz. sal-ammoniac, ½ lb. muriate of aniline dissolved in sufficient water. Give 7 turns quickly, wring well, and beat. Hang up evenly at 77° F. (25° C.) for 48 hours, and raise to 84° F. (29° C.). Take through either bichromate, or weak soda-lye; wash well. If reddish when dry, take through very weak chloride of lime liquor.

(6) Fast, for 60 lb. yarn.—Take through indigo vat. Then boil 5 lb. logwood extract, and 1½ lb. blue vitriol; steep yarns in this all night, and work in the morning, in 6 qt. nitrate of iron in sufficient cold water. Take through clear lime water, and wring out. Boil 5 lb. logwood extract, ¼ lb. fustic extract. Add this to sufficient hot water; work yarn in this for ½ hour; lift; add 2 lb. copperas; work again, wash off, and dry.

Blues.—(1) Methyl, 30 lb. yarn.—Dissolve 4 lb. Glauber salts, 2 lb. alum, in a sufficient quantity of water. Dissolve 1½ oz. methyl blue and add it to the dye-beck. Enter yarn at 110° F. (43° C.), turning rapidly, and dye to shade, raising the temperature to 120° F. (49° C.).

(2) Light, 50 lb. bleached yarn.—Dissolve 3 lb. alum, 3 oz. tartaric acid, and ¼ oz. "water-blue 6 B" (Berlin Aktien Gesellschaft für Anilin-Farben). Enter yarns at 110° F. (43° C.), turn rapidly, and raise the temperature to 130° F. (54° C.), turning to shade. After the colour has become level, another ¼ oz. of the colour, previously dissolved, should be added to the beck.

(3) Corn Flower (Pittacal).—Prepare the cotton in a cold solution of tannin; wring and enter into a solution of tartar-emetic. Wring, and enter into a solution of acetate of

pittacal, dissolved in acetic acid, diluted with a sufficient quantity of water, and then almost neutralised with ammonia.

(4) Navy, 11 lb.—Boil 2 lb. 3 oz. logwood, and dissolve in the clear hot liquid 26 oz. curd-soap. Steep clear yarn in this liquor for 2 hours at 167° F. (75° C.). Lift; add to the beck 26 oz. copperas; re-enter the yarns, and work till the colour is even. Wash in cold water, and work in a fresh beck with 17½ oz. curd-soap at 144° F. (62° C.), for 1 hour. Then make up a boiling beck with 2½ oz. of an aniline blue, soluble in spirit, and 2 lb. 3 oz. red liquor at 13° Tw. Work the yarn in this at a boil till the desired shade is obtained, and finally rinse.

(5) Aniline, 11 lb.—Boil 2 lb. 3 oz. sumach, or 6⅛ oz. tannin, in water; filter; dissolve 17½ oz. curd-soap in the clear solution, and enter the cotton over night into the hot liquor. Wring out, and make up a beck with acetate of alumina at 3° Tw., to which a clear solution of aniline blue is added according to the shade. Enter the cotton, and dye, raising the temperature to a boil for some time.

(6) Methylene.—This colour dyes cotton without a mordant, producing rich blues with a greenish reflection, fast against soap and light. It dissolves readily in water.

(7) Indigo or Vat.—Indigo being insoluble, cannot be applied to textile fibres by the ordinary dyeing process. It requires to be reduced to so-called "white indigo," when it becomes soluble, and is in that state deposited on the tissues of yarns, where it rapidly resumes its ordinary blue insoluble condition, and remains permanently fixed in the fibre.

In the case of cotton, the indigo vat is generally "set" in the following method. To about 2000 gal. water are added 60 lb. indigo, ground to an impalpable powder, 180 lb. slaked lime, and 120 lb. copperas. The lime and the copperas are added from time to time. The lime is put in first, and the vat is well stirred up before adding the copperas. There must be always sufficient lime present to dissolve the white indigo as it is formed. But if too much lime be present, an insoluble compound is formed, which renders the indigo useless for dyeing.

The yarns or pieces are simply steeped in, or rinsed through, the clear liquid of the vat, and then exposed to the air, when the greenish colour which they take at first is soon converted into a blue. The dipping and airing are repeated till the shade is obtained. The goods are then taken through very weak sulphuric acid, thoroughly well washed, and dried.

The vat for dyeing cotton, or any other vegetable fibre, is always worked in the cold.

An improvement in vat dyeing was invented and patented some years ago, by Schützenberger and de Lalande. A solution of the bisulphite of soda, at 52° to 63° Tw., is placed in a covered vessel, containing zinc clippings, borings, etc., piled up so as to fill the tank, without occupying more than ¼ of its total contents. After 1 hour's contact the liquid is drawn off into a cistern, containing milk of lime, which decomposes the zinc salts. The clear liquid is then strained off. Soda or lime sufficient to dissolve the indigo is then added, and it is mixed with the indigo, which must be in perfectly fine powder. At once is produced a yellow solution, containing no soluble impurities, except the earthy matters which were present in the indigo itself. Access of air is avoided as much as possible during this process. In this manner, 2 lb. 3 oz. indigo can be dissolved in 7½ to 26 pints of liquid. The vat is then filled with cold water, if for cotton, and a suitable amount of indigo solution is added. An excess of the "hydrosulphite" is always present, whence the reduced indigo solution is almost wholly avoided, the blue indigo being reduced as quickly as formed. The dye-liquor thus resists atmospheric action far better than the ordinary copperas vat, and is free from the inconvenience of always holding in suspension more or less peroxide of iron, carbonate of lime, etc., which must be allowed to settle before the vat can be used with advantage. By adding to the vat from time to time a little concentrated indigo solution, the strength can be maintained at any required point, and thus any given shade may be communicated by the smallest number of dips; the colours thus obtained are also brighter than those of the old process.

(8) Prussian, 10 lb.—Take 1 pint muriate of tin, 4 qt. nitrate of iron (so called blue iron), and 30 gal. water. Run the cloths or yarns 4 times through, and wash off.

Dissolve 1½ lb. yellow prussiate of potash (potassium ferrocyanide) in 30 gal. water, and add to it ½ pint oil of vitriol (full strength sulphuric acid). Run the piece, or turn the yarns, 4 times, and then raise the colour in a beck of 60 gal. water, ½ pint nitrate of iron, and ¼ pint oil of vitriol. Wash off, and dry.

Prussian blues are now almost entirely superseded by the coal-tar blues.

Browns.—(1) Fast, 110 lb. cotton yarns.—Dissolve 22 lb. catechu, and 2 lb. 3 oz. blue vitriol (sulphate of copper), in boiling water; steep for 1 hour in the boiling hot liquid; lift, drain, and then dye at a boil in 3 lb. 4 oz. bichromate of potash in fresh water; rinse, and dry.

(2) Fast Red, 11 lb.—Boil 2 lb. 3 oz. good cutch in water; let it settle; dissolve in the clear liquid 3½ oz. blue vitriol. Work the yarns for 1 hour at 212° F. (100° C.); wring out, and make up a fresh boiling beck with 4½ oz. chromate of potash. Work for ¾ hour, and rinse. Boil 3¼ lb. sumach in water; work the yarn in the liquid for ¾ hour at 190° F. (88° C.); lift; dissolve in the liquid 2¾ oz. tin crystals. Enter again, work for ¾ hour, and wring out. Make up a fresh beck with 2 lb. 3 oz. peach-wood, and 8¾ oz. alum, and work in this for 1 hour at 99° F. (37° C.).

(3) Dark, 60 lb.—Boil 18 lb. cutch, and 2 lb. blue vitriol, until dissolved. Add this to a hot water; give 3 turns, and let steep all night. Give one turn in the morning, and wring up. Dissolve 2 lb. chrome; add this to a hot water; give 2 turns, and wring up. Boil 2 lb. fustic extract and 2 lb. logwood extract till dissolved; add this to a hot water; give 4 turns, and lift; add 4 qt. copperas, and give 3 turns more. Wash in cold water, and dry.

(4) Light Blonde.—Boil 6 lb. cutch and 6 oz. blue vitriol till all is dissolved. Add this to a hot water; give the yarn 3 turns; let steep all night; give 1 turn more in the morning, and wring up. Add 1 lb. alum to a hot water; give 3 turns, and lift. Boil ½ lb. turmeric and ½ lb. extract of logwood together, and add this to the same liquor. Give 4 turns; wash in cold water, and dry.

(5) Bismarck, 100 lb.—Steep the yarns overnight in a decoction of 20 lb. sumach. Wring, and pass into a boiling bath, containing the colour previously dissolved in boiling water.

For darker shades, pass the cotton from the sumach beck into a cold beck of 6 lb. copperas, and let steep for ½ hour; rinse, and return to the sumach beck for ½ hour, and dye as above.

(6) Cinnamon, 10 lb.—Take through a catechu beck, marking 4° Tw., at a heat of about 180° F. (82° C.); give about 4 turns. Enter into a chrome beck at 1½° Tw.; give 3 to 4 turns, and wash. Enter into a water containing 30 gal. fustic liquor; give 3 to 4 turns, run off, and make up a fresh beck with 35 gal. sapan liquor and ¼ lb. annatto, previously dissolved. Give 3 to 4 turns; lift; add to the beck 1 gal. alum solution at 8° Tw.; give 3 to 4 turns; lift, rinse, and dry.

(7) Madder, for 10 pieces of 60 yd. each.—Pad the cloth in 6 gal. red liquor and 1 gal. iron liquor, to which about 6 gal. water have been added. Dry, and age for about 24 hours, when it is ready for dyeing. Run the pieces now through boiling water, in which chalk is suspended. Wash in the fly, rinse, and enter into a dye-beck of

40 lb. bark, and 20 lb. madder. Dye for 1 hour at 170° F. (77° C.); wash, and finish. Yarns may be dyed in a similar manner.

Chocolate, 11 lb.—Work the yarn for ½ hour at 167° F. (75° C.) in a beck of 8¾ oz. prepared catechu; lift, and take 5 to 7 times through a fresh beck at the same heat, made up with 1¼ oz. chromate of potash. Lift, and top in a fresh beck with $\frac{1}{10}$ oz. magenta, 16 gr. extract of indigo.

Claret, 11 lb. yarns.—Make up a beck with 17¼ oz. prepared catechu, and work the yarns in it for 1 hour. Wring, and steep for ½ hour in a hot beck of 6¼ oz. chromate of potash; take through cold water, and wash for ½ hour in a beck of 3¼ lb. sumach at 190° F. (88° C.). Dye in a cold beck with 1¾ oz. magenta, lift, add to the beck 8¾ oz. alum and the decoction of 2¼ lb. logwood. Enter again, work in the cold beck; lift, and add, according to shade, ⅓ to 1¾ oz. chromate of potash; re-enter, and work to shade.

Drabs.—(1) Light, 60 lb.—Boil 6 lb. solid extract of peachwood till dissolved; add the solution to a sufficient bulk of warm water; give the yarns 5 turns; lift, and add 1½ pint black liquor (acetate of iron). Give 3 turns more; wash in cold water, and dry.

For a medium shade, the process is similar; but double the quantity of black liquor is taken.

For a dark drab, boil 6 lb. cutch till dissolved; add to hot water, and work the yarns in it 5 turns. Run off the liquid and wring out the yarns. Dissolve 1½ lb. peachwood extract; add this to a warm water; work 5 turns; lift, and add 1 qt. black liquor; give 3 more turns; wash, and dry.

If a yellower shade is wanted, a little fustic is boiled with the peachwood; if redder, a little alum is used with the peachwood; and if browner, a little Bismarck brown.

The shades produced may also be varied by topping with aniline colours in small quantities.

(2) Silver, 60 lb.—Dissolve 2 oz. logwood extract; add the solution to a warm water; give the yarns 10 turns; lift, and add ½ pint black liquor (acetate of iron), and give 4 turns more. Wash in cold water, and dry.

Greens.—(1) Methyl, 11 lb.—Dissolve in boiling water $7\frac{1}{10}$ oz. tannin; lay the bleached cotton overnight in the hot solution; wring out; dye in cold water with a solution of the colour according to shade. Wring out, and dry in the dark without washing.

(2) For 22 lb.—For lighter shades, bleach well, and work in warm soap beck, to remove chlorine. Enter into a boiling lye of curd-soap, and wash out in cold water. Make up a cold dye-beck with 3 parts colour to every 100 of cotton, give 5 or 6 turns, and let steep overnight. Dry the next morning. If the shade is not full enough, take through the tannin beck, and dye again to shade.

For yellower tones, dye the cotton first a yellow, with fustic and alum, and then dye cold with the green. It must be remembered that this colour is turned to a violet shade by heat.

(3) Malachite.—This can be dyed in the same manner as methyl green; but it is not sensitive to heat, and admits, if required, of the presence of small quantities of acids.

(4) Cœruleine.—This colour dyes dark-green shades, though its name would lead us to expect sky-blues. For dyeing cotton, 2 lb. 3 oz. of the colour should be stirred up with twice its weight of bisulphite of soda at about 78° Tw.; the mixture may stand for some hours before it is added to the dye-beck.

The cotton yarns to be dyed are mordanted by passing alternately through chromate of potash and bisulphite of soda. The necessary quantity of colour, according to the shade required, is then added to cold water; the yarn is entered, and the heat is gradually raised to a boil. The shade obtained bears soaping and exposure to air, as well as do the alizarine colours.

(5) Dark, 50 lb.—Steep for 6 hours in a decoction of 10 lb. sumach; wring,

and enter into a fresh cold beck made up of 3 lb. alum, 9 oz. methyl green of a bluish shade, and 2 pails fustic liquor. Turn quickly, raising the temperature to 150° F. (66° C.); when the dye is exhausted, dissolve 3 to 4 oz. copperas in the same liquor, and give 3 to 4 turns, to sadden.

(6) Ordinary, 100 lb. yarn.—Dissolve 10 lb. nitrate of iron, and 1 lb. tin crystals; work the yarn in this solution cold; give 5 turns, and wring. In another beck dissolve 6 lb. yellow prussiate; give the yarn 5 turns in the cold solution; wring, and pass back into the nitrate of iron, and thence back into the prussiate beck, to which 2 lb. alum have been added; give 5 turns in each, and rinse.

Boil 40 lb. bark for 1 hour, strain into a tub, add 1 lb. sugar of lead, well dissolved; when all is well mixed, enter the yarn at 180° F. (82° C.), and work for ½ hour; lift, wring, and pass through another beck containing 2 lb. alum, and 2 lb. indigo waste. Rinse, and dry.

(7) Boil 25 lb. fustic in a bag, and add to the liquor 2½ lb. verdigris previously dissolved in vinegar and hot water; cool the dye; enter the yarn, which has been prepared overnight in a decoction of sumach; handle it well, and heat up to a boil, working for ½ hour. Cool it and enter it into another beck, containing a decoction of 10 lb. logwood. Heat up to a boil, and work ½ hour; take out, rinse, and dry.

If blue vitriol is used instead of verdigris, an olive green is obtained.

(8) Chrome.—Give the yarn a blue bottom in the vat; take through dilute sulphuric acid, and wash very well. Take through sugar of lead solution at 6° Tw., then through caustic soda lye at 2° to 3° Tw., and wash off. Enter into bichromate bath at 2° Tw. Each operation requires 5 to 6 turns. Wash off and dry.

Greys.—(1) Light, 11 lb. yarn.—Boil 4½ oz. sumach in 87 pints water; in this steep the yarn for 1 hour, turning frequently; lift, and add to the beck a decoction of 4½ oz. copperas; stir; re-enter, give 5 turns, steep for 15 minutes, and give another turn; let steep again, and turn once more; lift, and take through water. Wring out, and dry.

(2) Medium Mode, 11 lb.—Add to 44 qt. water at 100° F. (38° C.) a decoction of 17½ oz. sumach, 8¾ oz. logwood, and 4¾ oz. prepared catechu. Steep for 1 hour. Add 4¾ oz. nitrate of iron at 75° Tw.; re-enter, give 10 turns, and enter into fresh water at 100° F. (38° C.) with 2½ oz. chromate of potash.

(3) Light, on 60 lb. cotton pieces.—Boil 1½ lb. solid extract of logwood and ½ lb. extract of bark in sufficient water. Run the pieces 6 to 8 times through; press; and take through a fresh beck of 5 lb. copperas; rinse; and calender out of the following mixture: 45 lb. farina, 3 lb. wax, 6 lb. cocoanut oil, boiled to a stiff paste. Press, and dry.

(4) Fast, 22 lb.—1st operation: 35 fl. oz. olive-oil, and 2 lb. 3 oz. soda crystals. Work in this mixture at a boil for 30 minutes; wring and dry. 2nd operation: Grind 44 lb. coal very fine; add 22 lb. soda crystals, and 17½ pints of water at a boil. Mix the whole very well, and let steep for some hours. Then boil for ½ hour in 15 times the quantity of water; strain; and work the cotton in the hot liquid for ¼ hour airing well; pass 5 times through the same liquid, and wring each time. Wash first in lukewarm water, then in cold water; wring, and dry. 3rd operation: The dry cotton is passed into weak size, to which a little emulsive oil has been added. Wring, and dry. This grey resists soap, acids, and chloride of lime.

(5).Stone-shade, 25 lb.—Boil 25 lb. sumach, and 1 lb. fustic; enter the yarns into the decoction, to which a sufficient quantity of water has been added; give 5 turns; wring; and enter into a cold beck, with a solution of 1 lb. copperas (protosulphate of iron, or ferrous sulphate), and ¾ lb. blue-stone (copper sulphate). Give 5 turns, rinse, and dry.

Olive, 11 lb.—Extract 8¾ oz. sumach in boiling water; enter the yarn into the clear liquid ; let steep, and make up a fresh beck, with the same weight of copperas. Wring out the yarn, and enter into this second beck, working for ¼ hour. Wring, and enter into a fresh beck of red liquor at 1½° Tw. Give 12 hours ; heat to 144° F. (62° C.) ; wring out ; and work for ½ hour in the decoction of quercitron bark.

Orange.—(1) Full Lead, 60 lb.—Boil 12 lb. sugar of lead in 12 gal. clear lime-water till dissolved ; add to this enough cold water. Work yarn 5 turns, and wring. Repeat this process twice in the cold liquors, wringing after each time. Get a clear lime-water up to the boil, and give the yarns 5 turns in it, working very quickly. It is very important that the lime-water should be boiling, to keep the yarns level. Wash off in warm water with a little soap, and dry.

This colour, like all others in which lead is an ingredient, will be darkened and spoiled if exposed to fumes of sulphuretted hydrogen.

(2) Annatto, 60 lb.—Boil 6 lb. concentrated annatto with 2 lb. soap, and 2 lb. common soda, till completely dissolved ; add this to boiling water. Work the yarns 5 turns ; wash in cold water, and dry. This colour may be modified by topping with small quantities of magenta, etc.

(3) Aniline, 60 lb.—Boil 3 lb. tannic acid, and add the solution to warm water. Work the yarns 5 turns, and wring. Add 3 qt. nitro-muriate of tin to enough cold water, and mordant in the mixture. Wash well in cold water, with a little soap in the last water. Dissolve 12 oz. aniline orange, and add the solution to warm water. Give 5 turns, wash, and stove-dry.

Purple, 10 lb.—Prepare in stannate of soda at 10° Tw. ; pass in dilute sulphuric acid at 2° Tw. ; and give 2 washings in clear cold water. Fill up a tub with 30 gal. logwood liquor ; give 4 to 5 turns ; lift ; and add 4 qt. alum solution, and ½ pint double muriate of tin ; re-enter, and give 3 to 4 more turns. Wash off ; and prepare another beck with 30 gal. logwood liquor, and 10 gal. peach or sapan wood liquor ; re-enter, and give 3 to 4 turns ; add ½ pint purple spirit, and 4 qt. alum water. Give 5 to 6 turns ; wash, and dry.

Reds.—(1) Eosine.—These shades range from a cherry-red to a true rose, and have not the violet cast of magenta. For a more bluish shade, steep in a bath of curd-soap at 144° F. (62° C.) ; work for ½ hour ; rinse ; and work for the same length of time in subacetate of lead (basic sugar of lead) at 4° Tw. Rinse, and dye in a bath of eosine at 144° F. (62° C.). Soft soap must be used throughout the process. If yellower tones are required, alum is added to the sugar of lead beck, more or less according to the shade intended.

Eosine is also sometimes fixed upon cotton by mordanting in red liquor, and then passing through water in which chalk is suspended, when hydrate of alumina is deposited on the fibre.

(2) Rose Bengale.—This beautiful colour is fixed upon cotton as follows : Work the yarns for 1 hour in water, to which has been added 5 per cent. of the emulsive oil used for Turkey-red dyeing. Dry ; steep for 2 hours in cold red liquor at 3° Tw. ; and enter into the colour bath, which should contain ½ oz. of the dye, and ¾ oz. of the red liquor, to every 2 lb. 3 oz. of cotton. Work for 1 hour at 112° to 140° F. (44° to 60° C.).

The red liquor in question is made by dissolving 3¼ oz. alum in 17¼ oz. water, and adding 1⅞ oz. acetate of lime, previously dissolved in the same bulk of water. It is allowed to settle ; the clear is drawn off, and set at 3° Tw.

(3) Coralline, 11 lb. yarn.—Make up a hot beck with a decoction of 2 lb. 3 oz. turmeric. Work for ¼ hour ; take out, and rinse in cold water ; prepare another beck with 1¾ oz. soap, and 3½ oz. olive oil, the heat being 86° F. (30° C.) ; work the yarn in this for ¼ hour, and wring. Then dye in a cold solution of soluble red coralline, to which a trace of acetic acid has been added. The quantity of acid is greater or less, as a more or less yellowish shade is required.

(4) Boil in water 4¼ oz. white starch, and 4½ oz. white glue. Enter the cotton in this at 86° F. (30° C.); work for ¼ hour; rinse, and dye in a coralline beck at 86° F. (30° C.), as already described.

(5) Coralline and Aurine, 11 lb.—Aurine dye shades more inclining to orange than coralline. Boil 2 lb. 3 oz. sumach, or 6⅛ oz. tannin, in water, and soak the material all night in the clear hot liquid. Wring out next morning, and enter into a fresh beck of 17½ oz. good glue at 122° F. (50° C.). Wring out, and dye to shade in a cold solution of coralline. Wring again, and dry, without rinsing, in a room where the air is impregnated with ammonia. The cotton, if desired, may be grounded with turmeric and annatto, and merely topped with aurine.

(6) Galleine.—Galleine dyes deep and very solid reds. The yarns are mordanted in chrome alum, or by alternate passages through chromate of potash and bisulphite of soda. The requisite quantity of galleine is then placed in a bag, and suspended in a beck of cold water; the yarn is entered, and the heat is gradually raised to 212° F. (100° C.). The goods are then taken out, and the colour is developed by hot soaping.

(7) Colours derived from resorcine, such as the eosines, phloxine, etc., may be fixed in the following manner: The yarns are soaped hot with curd-soap for 1 hour, and wrung without rinsing. A solution is then made of 8¾ oz. alum, in 35 fl. oz. water, and diluted to 17½ pints; 1¾ oz. soda crystals are then added; the whole is allowed to settle, and the clear is drawn off. The cotton is steeped in this liquid, and kept at a boil for 10 to 12 hours; it is then passed into a bath containing 17½ pints water, and 6¾ to 10½ oz. emulsive oil, such as is used in Turkey-red dyeing. Before the oil is added to the bath, it should be very well shaken up with 35 fl. oz. water. The cotton is steeped in this liquid for 1 hour; then wrung, and dried. The dye-beck is then made up as follows: 17½ pints pure water, such as condensed-steam water, 7 fl. oz. red liquor at 7° Tw.; and the needful amount of colour. The dyeing is begun at 122° F. (50° C.), and the beck is gradually raised to 190° F. (88° C.). The goods are allowed to steep till the bath is exhausted; then wrung without rinsing, and dried. The red liquor is prepared by dissolving 4¼ oz. alum in 8¾ fl. oz. boiling water, and adding a solution of 3½ oz. sugar of lead in an equal bulk of water. The two solutions are mixed, allowed to settle, and strained; the clear liquid is set at 7° Tw.

(8) Scarlet on cotton, 100 lb.—Steep overnight in a decoction of 40 lb. sumach. Lift, and wring; enter in a bath of oxy-muriate of antimony at 3° Tw. Give 3 turns quickly; steep for ¾ hour, turning occasionally. Lift, wash well, wring, and enter into a colour-beck, made up with 10 oz. "extra scarlet" (of Sehlbach and Co.), and dye to shade at 110° F. (43° C.).

(9) Saffranine Scarlet, 60 lb. yarn.—Boil 10 lb. sumach; enter yarns; give 6 turns; let soak for 1 hour, and wring, enter into a fresh cold beck of nitro-muriate of tin at 2° Tw., give 6 turns, wash, first in warm, and then in cold water; wring well, and enter into a beck of 10 lb. turmeric. Finally, make up a beck with ½ lb. saffranine; enter yarns at 50° F. (10° C.), and raise the temperature to 120° F. (49° C.), turning continually. Wring, and dry.

(10) Pink, 50 lb. yarn.—Dissolve 5 lb. Glauber salts, and 4½ oz. "erysine" (of the Berlin Aktien Gesellschaft). Enter yarn at 120° F. (54° C.); give 5 turns quickly, and dye to shade, gradually raising the temperature to 140° F. (60° C.). To ensure even shades, it is better to add only half the erysine at first; and the rest, previously dissolved, by degrees.

(11) Magenta Ponceau, 10 lb.—Boil 2 lb. turmeric, strain, and steep the cotton in the liquid for 4 to 5 hours. Wring, and take through cold sours, containing about 10 oz. muriatic acid;

rinse well, and handle for 10 minutes in lukewarm water, containing 10 oz. starch, which has been boiled up to a paste with 1 oz. glue. Lastly, dye to shade in a fresh magenta beck. Magenta ponceaus and scarlets, even if the yellowest shades of the dye are taken, are never so satisfactory as those got up with eosine, saffranine, and other coal-tar colours, free from the violet tone of magenta.

(12) Alizarine Red.—Mordant in cold red liquor at 7° Tw. for 2 hours with frequent turning. Lift, wring, and air for 24 hours. Enter into a fresh beck, and dye at 212° F. (100° C.) with a solution of artificial alizarine.

(13) Cochineal Scarlet, 10 lb.—Boil 1 lb. annatto in a solution of 10 oz. potash for 20 minutes; cool a little; enter the cotton, work for 1 hour, lift, wring, and wash. Enter for ½ hour in a beck of permuriate of tin, marking 8° Tw., to which 2 oz. of tin crystals have been further added; lift, wring, and dye in a decoction of 1¼ lb. cochineal, beginning at a hand-heat, and gradually raising the temperature.

(14) Saffranine Rose, 11 lb.—Mordant with a decoction of 2 lb. 3 oz. sumach, or a corresponding smaller quantity of pure tannin, which is preferable. Dye in a clear solution of saffranine. If a shade verging towards a bluish-red is required, add to the sumach beck, before mordanting, 1¾ to 2¼ oz. tin crystals. Saffranine may also be fixed on cotton by means of red liquor, or soap.

(15) Safflower Pink, 60 lb. bleached yarn.—Add 1½ pint carthamine (extract of safflower) to the needful quantity of water. Work the yarns for 5 hours, giving a turn every ½ hour, and keep them in the liquid till all the colour is taken up. Wash off in 3 cold waters, adding 1 lb. cream of tartar to the last. Then dry, preferably by means of a current of cold air in the dark.

(16) Safflower Rose, 60 lb.—Work as above, but use double the quantity of carthamine, and take a longer time.

(17) Common Scarlet, 60 lb.—Boil 6 lb. sumach, and add decoction to hot water. Work yarns 5 turns, and wring; mordant in a tin solution (red cotton spirits). Wash in two waters, and wring up. Boil 18 lb. peachwood, and 18 lb. fustic, ground, and add the decoction to hot water. Work the yarns 10 turns, and raise with 1 lb. alum. Wash in cold water, and stove. For lighter shades, the sumach may be dispensed with, and turmeric may be used in place of fustic.

(18) Barwood Red, 10 lb.—Steep for 5 to 6 hours in a decoction of 2 lb. sumach to which a very little sulphuric acid has been added, turning from time to time. Wring out, and work in barwood spirits at 2° Tw. Wring, and enter into a beck of water at 200° F. (93° C.), containing 10 lb. rasped barwood; and work to shade at a boil.

(19) Turkey-red with artificial Alizarine.—The pieces are twice treated with 1⅝ oz. soda-ash a piece, each time for 18 hours; wring. Pad in oil at 160° F. (71° C.); hang up for 4 hours at 169° F. (76° C.). In padding, the lower roller should be dressed, and the upper not. Pad 5 times in the same oil bath, with both rollers dressed. After each padding hang up at 169° F. (76° C.). Pad in potash lye at 6° Tw. at 90° F. (32° C.). Pad in potash at 8° Tw., same heat. Pad in potash at 5° Tw., same heat. Pad in potash at 3° Tw., same heat. After each padding, hang up at 160° F. (71° C.). Pass through potash at 4° Tw., heated to 107° F. (42° C.). Extract the liquor, and take care that the pieces do not touch cold water. Hang up for 4 hours at 160° F. (71° C.). Pass into the following beck at 122° F. (50° C.): 2625 pints water, 17¼ oz. potash. Wash. and dry. Formerly, when the subsequent dyeing was performed with madder-root, there followed here the "galling" process—a treatment with tannin, which is no longer required, since artificial alizarine has come into use. The pieces are passed at once to the alum-bath, which is thus made up: To 110 lb. crystallised

alum, take 33 lb. soda crystals, and mix the solutions in water, stirring diligently. The clear liquid is finally set at 6½° to 7° Tw. The cotton is mordanted in this liquid for a day, and is then carefully washed, and wrung out, and is now ready for the dye-beck. To 110 lb. cotton are taken about 14 lb. 6 oz. alizarine (at 10 per cent.), and 17¼ oz. pure tannin. Raise very slowly to a boil during 2 hours, and keep up the boiling heat for another hour. The "cleaning process" (*avivage*), a treatment with soap and tin crystals, is not required, when working with good artificial alizarine. The cotton is at once bloomed with curd-soap, and a little annatto. It is to be remarked that if the water contains no lime, 3½ oz. of chalk should be added to the dye-beck for the above quantity of cotton. The oiling process is considerably simplified and abridged, by replacing the ordinary emulsive oil with the compound invented by Dr. Müller-Jacobs—a mixture of sulpho-ricinic and sulpho-pyroterebic acids in combination with ammonia. A single passage through this mordant supersedes the 5 successive oilings formerly employed. A small quantity of the compound is recommended to be added to the dye-beck.

Violet.—(1) Gentiana, 11 lb.—Boil 2 lb. 2 oz. sumach, or 6⅛ oz. tannin, in water, and steep the yarns overnight in the clear solution. Wring up next morning, and dye in a beck at 165° F. (74° C.), containing 9 oz. gum arabic, adding more or less of the dissolved colour, according to shade. Wring, and dry.

(2) Make up a beck at 122° F. (50° C.) with 80 gr. tannin for each 2 lb. 3 oz. cotton, and turn well for 4 to 5 hours. Wring, and enter into the colour beck at 110° F. (43° C.), adding 775 gr. acetic acid for 11 lb. cotton. Wring, and dry.

(3) Medium, 100 lb.—Mordant yarns in stannate of soda at 8° Tw.; sour at 1½° Tw. with dilute sulphuric acid; wash off with cold water, and dye with ¼ lb. aniline violet according to shade. Heat up to about 160° F. (71° C.).

Yellow.—(1) On 11 lb.—Dilute red liquor to 6½° Tw., and steep the clear yarns overnight in the cold. Extract 4 lb. 6 oz. quercitron bark in boiling water, let cool down to 167° F. (75° C.), and dye to shade. If a brighter shade is desired, add to the bark liquor 1¾ oz. tin crystals.

(2) Fast, on 60 lb.—Boil 6 lb. brown sugar of lead in 6 gal. water till dissolved; add it to sufficient cold water. Work the yarns 5 turns, and wring. Dissolve 2 lb. bichromate of potash, and add it to sufficient cold water. Work 5 turns, wash twice in cold water, and dry.

Calico Printing.—The following summary of recipes for calico printing are in the main condensed from an article by Sir W. Crookes, F.R.S., in 'Spons' Encyclopædia,' to which the reader may refer for greater detail and illustrations of machinery.

CHROME STANDARD.—2 gal. boiling water, 8 lb. bichromate of potash. Dissolve, and add 1⅖ gal. muriatic acid at 32° Tw. Stir gradually in 3½ lb. sugar.

The pieces, before printing, are bleached in the most perfect manner. After the so-called "colours" have been printed on, the next step is "ageing." In this process the goods are laid in bundles upon sparred floors, placed at different heights in the ageing house. The temperature is kept at 80° F. (27° C.), the wet-bulb thermometer marking 76° F. (24½° C.). The ageing process may last 2 to 3 days; its object is the decomposition of the acetates of alumina and iron in the mordants, so that either the bases or hydrated subsalts are left attached to the fibre.

The next step is "dunging," whose purpose is the removal of the thickeners, which have now played their part. The process was formerly performed with cow-dung. This material has, however, been almost entirely superseded by the double phosphate of soda and lime, the arsenite and arseniate of soda, and the silicate of soda. The pieces are passed through warm but weak solutions of these substances. This operation is often performed twice, the first time being called "fly-dunging"; and the next, "second dunging." When silicate of soda is used, the goods pass through two cisterns, heated to 122° F. (50° C.), or even 212° F. (100° C.), containing 738 gal. water and 19 gal. silicate of soda at 14° Tw., if the goods have been mordanted for brown and red, brown only, red only, and rose on a white ground. But if mordanted for black only, purple only, or purple and black, the proportion of silicate of soda is reduced to 13½ gal. at the same strength. The next step after washing is the dyeing with artificial alizarine, or anthrapurpurine. The colour is now permanently attached to the mordanted portions; but the whites are still stained or soiled, and the pieces are therefore submitted to the clearing process (*avivage*), which consists in successive treatments with soap-lye. A common treatment is two soapings at a boil, each time for ½ hour, with ¼ to ½ lb. soap. The pieces are washed in clean water after each soaping. The quality of the soap is of great importance: it should be quite neutral, and is made by preference from palm-oil. Freedom from alkalinity is especially important for madder-purples.

The following process has been employed in Alsace for clearing roses and reds: (1) Soap-bath; 2100 pints water, 9 lb. white curd-soap per 1000 yd.; time, 1½ hour; temperature, 122° F. (50° C.). (2) Washing in machine with cold water. (3) Bath of oxymuriate of tin: 1400 pints water, 10 lb. solution of tin per 10 yd.; time, 15 to 20 minutes; temperature, 133° to 143½° F. (56° to 62° C.). (4) Washing in machine. (5) Second soap bath: 2100 pints water, 6½ lb. soap; time, 45 minutes; temperature, 201° F. (94° C.). (6) Washing again in cold water. (7) Third soap-bath: proportions as in second. (9) Washing again in cold water. (9) Boiling in closed boiler, in 2100 pints of water, 5½ lb. soda crystals, 5½ lb. soap; time, 2 hours. (10) Washing in cold water. (11) Warm bath for ½ hour in water at 122° F. (50° C.).

Grass-bleaching is occasionally used in the clearing process for chintzes, cretonnes, etc., as it is considered to render the shades more transparent.

DISCHARGE STYLE. — By a "discharge" (*enlevage*), is understood a mixture which, if printed upon cloth previously dyed some uniform colour, e.g. Turkey-red, vat-blue, aniline-black, etc., destroys such ground colour, leaving a design which may be white, black, yellow, green, etc. The term "discharge style" is more especially applied to patterns of this nature obtained upon a Turkey-red. The following colours will serve as examples of these discharges:—

Black.—1 gal. logwood liquor at 4° Tw.; 2 lb. yellow prussiate; 1 qt. thick gum tragacanth water, 3 lb. flour. Boil, and add 2 qt. black liquor at 30° Tw. When quite cold, add 1 gill nitrate of iron at 80° Tw.

Blue.—5 lb. tartaric acid, 1 gal. water, 1 gal. tin pulp, 2 gal. double muriate of tin at 120° Tw., 2 gal. gum tragacanth water.

White.—(1) For cylinder work.—6 lb. tartaric acid, 1 gal. water, 1½ lb. starch.

(2) For block work.—10 lb. tartaric acid, 7½ lb. China-clay, 1½ lb. perchloride of tin, 1 pint gum water, 1 gal. water.

Yellow.—(1) Block.—1 gal. lime-juice at 50° Tw., 4 lb. tartaric acid, 4 lb. nitrate of lead. When dissolved, add 6 lb. China-clay, 3 lb. gum senegal.

(2) Cylinder.—Thicken the former with 1½ lb. starch, instead of gum and China-clay.

After any of these discharges is printed on, the pieces, when dry, are passed through the "decolouring vat," which is made up of 1000 gal. water and 1000 lb. chloride of lime, well raked up, and freed from lumps. A double set of wooden rollers at top and bottom is placed in the vat, and the liquid is kept constantly stirred up, so as to be uniform. The pieces are now allowed to run through the liquor at the rate of 28 yd. in 3 minutes. On leaving the vat, they are run between squeezing rollers into water, and are then rinsed for 10 minutes in solution of bichromate of potash at 4° Tw. Wash in pure water, then in water soured with muriatic acid, and lastly in pure water; after this, dry. Except where the discharge was printed on, the Turkey-red is unaffected; but there, it is removed, and either the ground is left white, or a mineral colour takes its place.

INDIGO EFFECTS.—Under this style, will be included the so-called "China blues"—designs in blue on a white ground; the kinds where reserves or resists are printed upon the cloth, which is then dyed in the vat, thus producing white, yellow, and orange designs on a blue ground; and lastly, the style named "lapis" or "lazulite."

Direct Indigo Blues.—(1) Put into a colour pan, 8 lb. 2 oz. indigo, finely ground in water, 4 lb. 6 oz. indigo in 26 pints liquid. Heat; and add 6 lb. 9 oz. ground gum. Dissolve; and add 11 lb. saturated hydrosulphite, 15½ oz. milk of lime, containing 7 oz. lime per 1¾ pint. Heat to 158° F. (70° C.), for 20 minutes; cool down to 104° F. (40° C.); and add 3 lb. 4 oz. saturated hydrosulphite, and 15½ oz. milk of lime. The yield is 30 lb. 12 oz. of colour.

(2) Mix 22 lb. *bleu gommé* (explained below), 13 lb. 2 oz. gum water, 15 lb. 5 oz. saturated hydrosulphite, and 32¾ oz. milk of lime.

These colours must always be used warm, never under 80° F. (30° C.), nor over 95° F. (35° C.). Nor must they be used too soon after they are prepared. Those colours give the best results, which show a greenish hue till the next morning.

When the colours are printed, the pieces are spread out overnight in an airy place, or, if necessary, they may immediately after printing be passed through a weak lukewarm chrome beck. In either case they must be very well rinsed, washed, and soaped, for 30 to 45 minutes at 122° to 140° F. (50° to 60° C.). If the whites are not good, they are taken through weak chloride of lime. If this lime is printed along with other colours, the pieces may undergo the treatment necessary for such colours, without any attention being paid to the blues. Passing through soda, sulphuric sours, chrome baths (warm or cold), alkaline, chrome and lime baths, silicate of soda, phosphates of lime or soda, cow-dung, etc. has no effect on these blues.

The *bleu gommé* is prepared as follows: 4 lb. 6 oz. good Bengal indigo are ground up in the ordinary manner employing water enough to make the paste up to 35 pints. This is placed in a boiler, made up with water to 105 to 140 pints, along with 11½ lb. caustic soda-lye at 62° Tw. and 30¾ lb. hydrosulphite of soda. It is heated to about 156° F. (70° C.) for 15 to 20 minutes. Then 131 fl. oz. hydrochloric acid are poured in through a long-necked funnel, reaching to the bottom of the vessel. This operation should be performed under a chimney, as much sulphurous gas is given off. If the liquid has a faintly acid reaction, the decomposition is complete, and the whole is poured into a cask capable of holding 280 pints, which is filled up with water. The next morning, the liquid standing over the sediment is run off through holes in the sides of the cask, till the bottom is only covered to the depth of 9 to 10 in. The vat is then filled anew with water, to which 4 per cent. by measure of saturated hydrosulphite is again added. The next day the water is again drawn off, and the sediment is thrown upon a filter, and washed. When completely drained, 7 lb. of a dense paste are obtained for every 2 lb. indigo originally employed. To preserve this paste, it is suspended in gum water. The yield, as above, is mixed with 44 lb. thick gum water, containing in each 1¾ pint 3 lb. 1 oz. gum. This mixture is the *bleu gommé*. Gum senegal should be used, as starch, calcined starch, and tragacanth have given bad results.

Lapis resist, white (for block and

machine).—5½ pints water, 6 lb. 9 oz. lime-juice at 53½° Tw., 11 lb. pipe-clay. Mix also separately: 5½ pints water, 4 lb. 6 oz. lime-juice at 53½° Tw., 3 lb. 13 oz. corrosive sublimate, 11 lb. calcined starch, 12¾ oz. lard, 6½ oz. turpentine, 3¼ lb. muriate of zinc at 98° Tw. Mix and boil.

Lapis resist, red.—7 pints red liquor 6⅝ oz. verdigris, 9 lb. 13 oz. pipe-clay 4⅞ oz. lard, 4⅞ oz. turpentine. Dissolve also separately: 12¾ oz. arsenious acid, 5½ pints acetate of alumina. Mix also apart: 3½ pints acetate of alumina, 3¼ lb. gum senegal, 17¼ oz. muriate of zinc at 98° Tw., 8¾ fl. oz. extract of logwood at 6¾° Tw. Mix these three parts with the aid of heat, grinding them very well, and straining before use.

The cylinders for printing should be engraved very deeply. The pieces are next aged for 48 hours at a temperature of 95° F. (35° C.) with the wet-bulb thermometer at 89° F. (32° C.). Dry for 12 hours thoroughly at 86° F. (30° C.). If left damp, the pieces will not resist the vat. Dye blue for 3 to 5 minutes in the cold vat. Drain, wash for ¼ hour in a current of water. Dung in folds for ½ hour in a beck at 140° F. (60° C.), with 4 pails of dung, and 15¼ lb. chalk, for 6 pieces of about 50 yd. Wash; and dung a second time in the same matter, but without chalk; and wash. Dye for 2 hours at 144° to 158° F. (60° to 70° C.), in the following beck: 8 lb. garancine (for which will now be substituted a proportionate quantity of alizarine), 6 lb. 9 oz. sapanwood, 11 lb. sumach, 17½ lb. bark, 7 pints glue in jelly (containing 17½ oz. dry glue). Wash till no more colour runs off; chlore at ¾° Tw. Wash; dry; block in yellow, if needed; and age for 24 hours at 86° F. (30° C.), the wet-bulb thermometer standing at 80° F. (27° C.).

Lightfoot's process for combining indigo and madder effects.—1¼ lb. dry indigo, ground and prepared, 1¼ lb. tin crystals, 1 gal. caustic soda at 30° Tw.; put into the colour pan, and raised to a boil in ½ hour, when 1 gal. boiling water is added. The mixture is then allowed to become quite cold, and 2 gal. cold water are added, in which ½ lb. sugar has been previously dissolved. To this solution are added 2½ pints muriatic acid at 32° Tw., or 1 pint ordinary oil of vitriol, previously diluted with 1 pint water, and allowed to stand till cold, or 3 qt. acetic acid at 80° Tw. The indigo blue may also be precipitated by a mixture of double muriate of tin at 120° Tw., with any of the acids above mentioned, taking ¼ pint of the tin solution to half the quantities of acid given above. But of all these precipitants, acetic acid alone is preferable. The indigotine precipitate is filtered through a deep conical filter leaving exposed to the air as small a surface as possible. The pulp obtained from the above quantities, when filtered, should measure about 1 gal. To make a blue colour for printing, take 4 gal. of the above precipitated indigo, and 14 lb. gum senegal in powder, stirring till dissolved. The colour when strained is ready for printing. For a green colour, take 4¼ gal. indigotine precipitate, 18 lb. powdered gum senegal, stirring till dissolved; 11 lb. nitrate of lead, and 11 lb. white sugar of lead, both in powder. The mixture is stirred till all is dissolved, and is then strained. Compound colours are made by mixing the blue and green with each other, or with ordinary mordants for dyeing. With the blue and green above described, and with the ordinary iron and alum mordants (as used in madder-work), print calico, and, after cooling, age the pieces for a night. They are then fixed by passing into a solution of silicate of soda at 8° Tw., to which is added 1 oz. powdered chalk in 1 gal. This bath is in a cistern fitted with rollers at top and bottom, and heated to 90° F. (32° C.). The pieces pass through this solution at the speed of 25 yd. a minute. They are then rinsed in a tank of cold water, fitted with a reel about 4 ft. above the surface. By this process the indigotine attached to the fibre is rendered blue. If the green mixture has been printed, the pieces are next passed into a chrome beck at 100° F. (38° C.), containing 1 oz. bichromate of potash in 1 gal. of water. Here the pieces remain for 5 minutes, and are then washed. They are next submitted to second dunging (the passage through silicate of soda being the fly dunging) for 15 minutes, at 100° F. (38° C.), in a beck of cow-dung and water. They are next washed in water, and dyed with madder, munjeet, flower of madder (alizarine), garancine, cochineal, or mixtures of garancine with sumach and bark. The grounds are then cleared in the ordinary manner, preferably with chloride of lime.

White Reserve.—(1) Block.—3 lb. blue-stone, 1 gal. water, 15 lb. pipe-clay. Beat up with some of the solution; mix gradually to a smooth paste, and add 1 gal. thick gum senegal water, and 1 qt. muriate of copper at 80° Tw.

(2) Machine.—2½ lb. blue-stone, 1 gal. water, 9 lb. flour, 2 lb. British gum (dark).

White resist (for lighter vat-blues).—25 lb. dark British gum, 15 lb. water. Boil for 10 minutes; and add 7½ lb. soft-soap. When thoroughly incorporated, add 20 lb. sulphate of zinc. Stir in well, and add further: 7½ pints water, 10 lb. pipe-clay, 7½ gal. nitrate of copper at 80° Tw. Work all thoroughly together.

Orange Reserve.—Heat 2 lb. water to a boil, and add, with constant stirring, 1 lb. sugar of lead, and ½ lb. litharge; boil for 20 minutes, and add to the liquid, to which more water must be supplied, to compensate for the loss by evaporation, 1 lb. blue-stone, 2 lb. nitrate of lead, and 1½ oz. verdigris, previously softened in acetic acid. The whole is let stand for a day, with frequent stirring; 1¼ lb. powdered gum senegal, and 1 lb. sulphate of lead, are then stirred in; and lastly, 2½ oz. powdered sal-ammoniac, and 1 oz. lard are added. If the colour is too stiff, it is diluted with water. It is then strained, and printed on at about 122° F. (50° C.). Age for a day or two at 66° to 77° F. (19° to 25° C.). Dye in the cold vat; dry, and sour at ¾° Tw. For raising the orange, take for 100 yd., 175 pints water, containing 8 lb. chromate of potash, and 16 lb. lime. Let settle; run off the clear, and heat to a boil, at which temperature the pieces are passed through at such a speed that each part may occupy 3 minutes in traversing the liquid. Rinse well.

Yellow Reserve.—20 lb. blue-stone, 2 gal. water, 20 lb. nitrate of lead. Dissolve; and thicken with 12 lb. flour, 2 gal. sulphate of lead pulp. Boil well together. The sulphate of lead pulp here mentioned is the sediment left on making red liquor with solution of sugar of lead and alum (or sulphate of alumina), after the liquid has been run off.

Blues.—To produce a pale-blue pattern on a deep-blue ground, the entire pieces are first dyed a light shade in the vat. They are then withdrawn, thoroughly washed in water, taken through vitriol sours at 2° Tw., washed again, squeezed, and dried. One of the white reserves is then printed on, and the pieces are returned to the vat, and dyed the darker shade. The reserved parts appear as a pale-blue pattern on a deep-blue ground.

To obtain a design in two blues on a white, muriate of manganese is printed on, thickened with dark British gum, and is then peroxidised by being passed through chloride of lime and soda, as in the production of "bronzes." The goods are then dried, and those parts of the pattern which are to appear white are printed with a white reserve. The goods are next limed, vatted to shade, taken out, aired to oxidise the indigo, washed, and rinsed in weak muriate sours, to which a little protochloride of tin has been added. The pattern appears then in white and dark-blue on a light-blue ground, the white being where the discharge was applied, and the dark-blue where the indigo is fixed upon a bottom of manganese brown.

If yellow or orange is to be obtained in addition, the yellow or the orange reserve is blocked in beside the muriate of manganese and the white reserve. Vitriol sours must be used here, and the yellow is then developed by a passage through bichromate of potash at 100° F. (38° C.), containing 2 oz. per gal. Wash in water, and pass through muriate sours at ½° Tw., with the addition of 1 oz. oxalic acid per gal.

If a blue and green design is intended, the yellow discharge given, or one of a similar character, is printed on, and the goods are dipped in the vat to a full blue, washed, aired, washed again, taken through vitriol sours at 2° Tw., washed again, and passed through the bichromate beck, but without any treatment in oxalic-muriatic sours. The green is formed by the combination of the yellow and the blue.

To produce two shades of the blue with a green, the cloth is vatted to a pale-blue, a white reserve for light shades, and an orange reserve, are printed in. The usual operations are then gone through; but after the bichromate process, the pieces are taken through nitric acid, which must be very dilute, otherwise the indigo may be destroyed. The result is a dark-blue ground, with a design in pale-blue where the white resists have been applied, and in green where the orange has been printed.

Discharges on Vat-Blues.—Give a medium blue in the vat. Steep pieces in bichromate of potash (4⅜ oz. in 1¾ pint water), and dry on rollers, avoiding sun-light. Print on the following discharges :—

White.—7 pints water, 2 lb. 7¼ oz. white starch. Boil, and add while still warm, 2 lb. 3 oz. tartaric acid, and then 21½ oz. oxalic acid, dissolved in 1¾ pint water.

Red.—14 qt. red liquor, 17½ lb. white starch. Boil; let one half grow cold, and add to it 7 lb. 10 oz. oxalic acid. Then add the other half of the hot mixture to complete the solution of the acid.

The red liquor consists of 2 lb. 3 oz. alum, the same weight acetate of lead, 3½ pints water.

Print on the white and red discharges with the perrotine, or with a two-colour cylinder machine. Do not dry too strongly. Age in hot, but not moist, air, which is an essential condition. The next morning, dung as follows: Into a beck with rollers, put 6 lb. 9 oz. neutral arseniate of potash, 27 lb. 7 oz. chalk, and 1750 pints water. Pass the pieces slowly through at a simmer, so as to keep the chalk in suspension. After leaving this beck, the pieces are strongly compressed between two rollers covered with cloth. After the first 5 pieces have passed, feed the beck with 1¾ oz. arseniate of potash, and a little chalk, per piece. After thus cleansing the pieces, dye up in alizarine, and take through boiling water.

Green and Yellow on a Deep-blue Ground.—Boil the pieces with 2 lb. 3 oz. soda-ash per 100 yd.; wash well, and take through a weak soda beck, containing per 100 yd., 8¾ oz. soda-ash at 100° F. (38° C.). Dry, calender, and dye a blue in the cold vat. Take through sulphuric acid at 1·4° Tw., starch slightly, dry, and calender cold. Print the following colours on the blue ground :—

(1) Green Discharge.—26¼ lb. pipe-clay, 6 lb. 9 oz. gum arabic, the same weight of blue-stone, and of verdigris, 13 lb. 2 oz. nitrate of lead, and 6 lb. 9 oz. sugar of lead. The verdigris is dissolved in acetic acid, and the gum in water; the two solutions are stirred together, and the pipe-clay, previously softened in water, is added. The other ingredients are powdered, and stirred in by degrees. Water is added, enough to make the mixture fit for printing; when it is boiled, the water lost by evaporation is replaced, and the colour is then ready.

(2) Yellow Discharge.—19 lb. 11 oz. pipe-clay, 2¾ lb. verdigris, 2 lb. 7¼ oz. blue-stone, 3¾ lb. nitrate of copper, the same weight of gum arabic, 15½ pints water, 6¾ lb. nitrate of lead, the

same weight of sugar of lead, and 4 lb. 6 oz. nitric acid at 143° Tw. Make up the colour without the nitric acid, stir all well together, and stir in the nitric acid just before using.

Print on first the green and then the yellow. Age in the cold, till the discharge becomes visible on the back of the pieces. Take them through a weak vat to wet them, and then dye up to shade in a fresh vat. Sour without drying, wash off the colours, rinse, take through weak lime-water to remove the acid, and then through a beck of chromate of potash, containing 3¼ lb. chromate per 87 qt. water. The pieces are caused to move very slowly, so that the dyeing process may go on satisfactorily. Rinse, dry, stiffen, and calender.

MADDER COLOURS.—This style on the Continent is generally characterised as "dyeing mordants," or "dyeing upon mordants," a preferable name, since the essence of the style is that merely mordants, duly thickened, are printed upon the pieces. The cloth is then worked in a dye-beck (formerly with madder, now with coal-tar alizarine and anthrapurpurine), as if the object were to produce a uniform colour. As, however, the mordants have been applied to certain parts of the surface only, the colour attaches itself to these alone, producing the design. The colours thus obtained are then cleared or brightened, and the white ground is freed from all traces of colour.

The subjoined are some of the more important of the mordants (called by the misleading name of "colours") printed on for the production of special effects in the madder style :—

Black (for machine work).—4 gal. black liquor at 34° Tw., 4 gal. crude acetic acid, 4 gal. water, 24 lb. flour. Grind the flour to a smooth paste with a little of the mixed liquid, stir in the rest, boil, and stir in 1 pint of gallipoli. No clots must be allowed to remain.

It must be noted that blacks are less frequently produced by the madder style than was formerly the case, as the aniline black is more and more taking their place.

Brown Standard.—50 gal. water, 200 lb. catechu. Boil 6 hours, and add 4½ gal. acetic acid. Make up to 50 gal. with water. Let stand for 2 days; decant the clear, heat to 130° F. (54° C.), and add 96 lb. sal-ammoniac, dissolve, and let settle for 48 hours, decant the clear, and thicken with 4 lb. gum senegal per gal.

For machine work.—8 gal. brown standard, as above, 1 gal. acetate of copper, as below, ½ gal. acetic acid, ½ gal. gum senegal water (4 lb. a gal.).

To make the acetate of copper, take 4 lb. blue-stone, 4 lb. sugar of lead, 1 gal. hot water. Dissolve, let settle, and set the clear at 16° Tw. with water.

Madder Brown to resist heavy covers of Purple.—½ lb. catechu, ¼ lb. sal-ammoniac, 1 qt. lime-juice at 8° Tw., 2½ oz. nitrate of copper at 80° Tw., 1½ oz. acetate of copper, 1 lb. gum senegal.

Chocolate.—3 gal. iron liquor at 24° Tw., 6 gal. red liquor at 18° Tw., 14 lb. flour, 1 pint logwood liquor.

Drab.—4 gal. brown standard, 1 gal. protomuriate of iron (ferrous chloride) at 9° Tw., 3 gal. acetate of copper, 1 gal. gum substitute water, containing 4 lb.

Purple.—Add to the iron liquor, in proportions varying according to the shade, 40 lb. light British gum, 16 gal. water, 2 gal. purple fixing liquor. Boil well together; draw off, and allow the whole to stand for 3 to 4 days. Of this 8 to 30 gal. may be added to 1 gal. black liquor.

Padding Purple.—Make up a thickener as follows: 13½ gal. water, 2 gal. purple fixing liquor, 2 qt. logwood liquor at 8° Tw., 18 lb. flour. Boil, and add 2½ gal. of farina gum water, made by boiling 6 lb. dark calcined farina in 1 gal. water.

Purple Fixing Liquor.—(1) 7½ gal. water, 1½ gal. acetic acid, 9 lb. sal-ammoniac, 9 lb. arsenious acid. Boil till all the arsenic is dissolved; let stand to settle, and decant off the clear for use.

(2) 2 gal. water, 25 lb. soda crystals, 22½ lb. white arsenic. Boil till dissolved, and add 50 gal. raw acetic acid, which should first be heated to 120° F. (49° C.). Let settle for some days ; decant off the clear, and add 3 qt. muriatic acid at 32° Tw.

Purple Assistant Liquor.—100 lb. potato starch, 37½ gal. water, 123 gal. nitric acid, at 60° Tw., 4 oz. black oxide manganese. When the reaction is over, and the nitric acid is destroyed, add 50 gal. pyroligneous acid.

Red, dark (for machine work).—6 gal. red liquor at 18° Tw., 12 lb. flour.

Standard Red Liquor.—20 lb. alum, 12½ lb. sugar of lead, 5 gal. boiling water. Stir till dissolved ; let settle, and draw off the clear.

Dark Red, for resisting a chocolate cover.—12 gal. resist-red liquor (see below) at 18° Tw., 24 lb. flour. Boil well, and when almost cold, add 12 lb. tin crystals.

The resist-red liquor consists of 90 gal. acetate of lime at 24° Tw., 272 lb. sulphate of alumina, 34 lb. ground chalk

Red, for resisting purple covers.—6 gal. resist-red liquor at 14° Tw., 12 lb. flour ; boil ; when nearly cold, add 2¼ lb. tin crystals.

White figures are obtained by printing on some mixture like the following : 1 gal. lime-juice, at 8°, 20°, or 30° Tw., 1 lb. starch. Boil, and stir till dissolved. Where this so-called "acid" is printed in, covers and padded grounds subsequently printed take no effect, and the figure remains white. Upon such whites, steam colours may be afterwards blocked in, and thus a great variety of effect is obtained.

MANGANESE BRONZE STYLE. — A brown ground is produced over the entire surface by padding in solutions of a salt of manganese, drying, padding in soda-lye, first at 24° Tw. then at 12° Tw., rinsing in water, taking through bleaching lime at 2° Tw., washing again in water, and drying. By these processes, manganese peroxide is uniformly deposited over the fibre. Various colours are then printed upon this ground, so made up as to discharge it, and become fixed in its place, the result being designs in white, black, red, green, blue, yellow, etc., on a brown ground. After printing, the pieces are hung up for a few hours, rinsed in a flow of water, in chalk water, then in pure water, and, in case of chrome yellow greens, in a solution of bichromate of potash at about 40° Tw. Lastly, the goods are washed and dried. As specimens of the discharge colours printed on, the following are given :—

Pink.—1 gal. Brazil-wood liquor at 12° Tw., 2 oz. blue-stone, 2 oz. sal-ammoniac, 2 lb. starch. Boil, and add 8 fl. oz. oxymuriate of tin at 120° Tw. Mix 2 qt. of the above colour with 1 qt. double muriate of tin at 120° Tw.

White.—2 gal. water, 8 lb. light British gum. Boil, and add 8 lb. tartaric acid, 1 gal. double muriate of tin at 120° Tw.

PADDING STYLE.—This is a modification of the madder style. The pieces are padded over with red and black liquor, dried in the so-called padding-flue ; the pattern is printed on in lime juice and bisulphate of potash, thickened generally with starch, thus removing the mordant from certain parts. After ageing, dunging, and dyeing, the design appears in white on a claret, scarlet, or purple ground. It is, of course, easy to convert the white design into a yellow, or to block in steam or pigment colours.

PIGMENT STYLE.—The colours employed in this style are insoluble pigments, which are fixed upon the fibre by various mediums, and offer the advantages of solidity and permanence, combined with a lightness and brilliance equalling, in many cases, those of colours formed in the fibre. The pigments chiefly employed are ultramarine of various shades, from greenish-blue to a full blue, violet-blue and even a reddish - violet ; vermilion ; several ochres ; zinc-white ; certain chrome colours, such as chrome-yellow, chrome-green, Guignet's green, Wilner's green, lampblack, sienna, umber, etc. The vehicles or mediums for attaching these pigments to the fabric are albumen and caseine (often called lactarine). Blood-albumen may be used for all save the lightest and brightest colours. The pigments are ground up in albumen, thickened often with gum tragacanth, printed and steamed. The albumen is thus coagulated, and the colour is permanently attached to the fibre. Pigment printing is chiefly confined to such parts of designs as consist of small dots, stars, and flowers ; more rarely to broad stripes, large foliage, etc. It affords the means of producing many pleasing effects which would not otherwise be practicable. Pigment colours, and other colours fixed by means of albumen, may be discharged by printing in the juice of the papaw-tree (*Carica Papaya*), thickened with gum.

Aniline Black.—(1) For Yarn Printing.—1¾ pint gum tragacanth water, 2⅛ pints water, 9¾ oz. sublimed aniline muriate, 2¾ oz. chlorate of potash. Immediately before use, work in 2¾ oz. sulphide of copper. The colour thus made is printed ; the pieces are dried and aged for 48 hours at 86° F. (30° C.) in a moist atmosphere. As soon as the colour appears of a blackish-green, the yarns are washed, taken through weak bichromate of potash, then through a solution of soda, washed and dried.

(2) For Machine Work.—159 oz. each chlorate of potash and sal-ammoniac, 150 oz. moist sulphide of copper, 360 oz. white starch, 180 oz. calcined starch, 2300 oz. water. Boil, stir till cold, and add 317 oz. sublimed aniline salt, previously dissolved in 9000 oz. cold water.

(3) Prussiate.—34 oz. chlorate of aniline, 12 oz. prussiate of aniline, 34 oz. water, 12 oz. gum tragacanth water (containing 4⅝ oz. per 1¾ pint). This mixture may also be thickened with starch paste, both for block and machine work. The chlorate of aniline is prepared by dissolving 5 oz. tartaric acid in 10 oz. boiling water, and, separately, 4 oz. chlorate of potash in 12 oz. boiling water. These two hot liquids are mixed together, 20 oz. cold water and 3 oz. aniline being added. After this addition, the liquid takes a faint yellowish tinge, and stands at 9½° Tw. To obtain a prussiate of aniline, treat 7 oz. yellow prussiate with 3 oz. sulphuric acid, previously diluted with 14 oz. water. After some days the yellow colour disappears, and a deposit of sulphate of potash is formed. To 100 oz. of the solution thus obtained, are added 128 oz. of water and 20 oz. aniline.

(4) White Discharge upon Aniline Blacks.—Thicken an acid solution of the permanganate of potash with finely-ground siliceous earth and China-clay, and block on. Take through oxalic acid when dry. No organic matter must be used for thickening the permanganate.

(5) Aniline Black, with Design in White, Madder Red, and Chrome Orange.—This process illustrates the manners in which aniline black may be combined with other colours. For the madder red, is used a mordant of red liquor at 12° Tw., thickened with 2¼ lb. flour per gal. Cool, and add, per gal., 4 oz. tin crystals. For the orange, dissolve 4½ lb. nitrate of lead, 4½ lb. white sugar of lead, in ⅓ gal. water. Add ⅔ gal. gum Barbary water (6 lb. to the gal.). For the black, mix 1 gal. of the colour below, just before printing, with ½ pint sulphide of copper paste. To make the colour, thicken 6 gal. clear chlorate of ammonia with 36 lb. British gum. Heat to 150° F. (66° C.), let stand till cold, and add 4 qt. aniline oil, and 3 qt. best muriatic acid at 34° Tw. Mix well together. To make the chlorate of ammonia, dissolve 7½ lb. tartaric acid in 6 gal. boiling water. When dissolved, add gradually 3 lb. 2 oz. sesquicarbonate of ammonia. Now add 8 lb. chloride of potash, and stir till dissolved. Let stand till cold, and filter. Wash the precipitated tartar (potassium bitartrate) with 6 qt. cold

water. This should yield 6 gal. clear chlorate of ammonia solution. For the sulphide of copper, take 2 lb. 2 oz. flowers of sulphur, 11½ lb. caustic soda lye (70° Tw.). Stir well till dissolved, without heat; add it to 10 lb. bluestone, dissolved in 20 gal. boiling water. Wash till neutral to test-paper, and filter till the bulk of the paste is reduced to 1 gal.

Print the above black, red, and orange colours, and hang in a room at 70° F. (21° C.) with about 8° to 9° F. difference between the wet- and dry-bulb thermometers. Age till black, and pass through ammonia gas. Hang in a cool room for a few hours, and pass through the following solution at 160° F. (71° C.): 2 lb. sulphate of soda, 1 oz. phosphate of soda, 1 gal. water. Wash, and give a second dunging for 25 minutes at 130° F. (54° C.) in 100 gal. water, 2 lb. sulphate of soda, 1 oz. phosphate of soda, and 4 qt. solid cow-dung. Wash, and dye with 13 lb. madder, or a proportionate quantity of alizarine, per piece. Wash, pass through chloride of lime at 1° Tw., then steam, and wash. Dry, and steam for ½ hour at 2 lb. pressure. Wet out, soap-wash, and pass through weak sours (1 part oil of vitriol at 170° Tw., to 1000 water) at 60° F. (15° C.) for 6 minutes. Wash, and pass through chloride of lime, as before. Wash, dry, and raise orange in the usual way, first in the bichromate alone, and then in bichromate and lime at 212° F. (100° C.). Wash well, and pass through chloride of lime, as before. Wash, and dry.

(6) Dissolve ⅞ to 1¼ oz. chlorate of soda in 17 fl. oz. water, and thicken as usual. In another vessel, thicken 17 fl. oz. water, and stir in 2¾ oz. muriate of aniline, with 1½ gr. chloride of vanadium. Equal measures of these two solutions are mixed, and printed at once. Age at a low temperature, as long as chlorine is given off, and raise the temperature till perfectly dry. Lastly, pass through a solution of bichromate of potash, wash, and dry.

(7) The cerium aniline black, of Jerens, is obtained by mixing 75 gr. bisulphate of cerous oxide with 2¾ oz. muriate of aniline, thickened as usual. The shade, after printing, appears a light green, but after ageing for 24 hours at 77° F. (25° C.)—68° F. (20° C.) by the wet-bulb thermometer—it turns to a dark-green, and, after soaping and taking through an alkaline beck, it comes up a fine black.

PLATE STYLE.—This is a modification of the madder style. For a "plate purple," a purple is printed on, and an "acid" as described, and the whole is covered over with a lighter purple. The pieces are then aged in the normal manner; fly-dunged at 170° F. (77° C.); and dunged a second time at 165° F. (74° C.). They are next washed and dyed, raising the temperature in 2 hours to 175° F. (79° C.), which heat is kept up for ½ hour. Wash, and soap, taking 1 lb. soap for 3 pieces of 30 yd. each, boiling for 30 minutes. Wash, and take for 5 minutes through a beck of 500 gal. water, with ½ gal. solution of chloride of lime at 8° Tw. Rinse; boil for ½ hour with 1 lb. soap per 5 pieces; wash; chlore again for 5 minutes; wring in 1 gal. bleaching liquor at 8° Tw., in only 200 gal. water, along with 2 lb. soda ash at 160° F. (71° C.).

RESERVE STYLE.—This is another modification of madder-work. Acid reserves, consisting of lime-juice and caustic soda, are printed on the pieces; next, the ordinary "colours" for madder reds, purples, chocolates, etc., are printed; and the goods, after the usual operations of ageing and dunging, are dyed. In the white portions reserved, steam or pigment colours may be blocked in.

SPIRIT COLOUR STYLE, OR APPLICATION COLOURS.—The colours employed in this style contain so large a proportion of acid mordants, chiefly the chlorides of tin (or, as they are technically called, "spirits"), that steaming would be impracticable. After printing, the goods are carefully dried, aged for a few hours, rinsed, washed with cold water, and are then ready for drying off. The colours are bright, but, as a rule, not enduring; and the cloth is often weakened by the action of the strong mordants. The colours bear a considerable resemblance to those employed in the steam style. The following are examples :—

Block Blue.—1 gal. water, 1 lb. yellow prussiate, 6 oz. alum, 20 oz. starch. Boil, and after letting cool down to 110° F. (43° C.), add 15 oz. nitrate of iron at 80° Tw., and 15 oz. oxymuriate of tin at 120° Tw.

Brown.—1 gal. berry liquor at 80° Tw., 2 lb. light British gum. Boil, and add 1 lb. tin crystals, and 2 qt. each of the pink and purple colours given below.

Chocolate.—3 qt. sapan liquor at 8° Tw., 2 qt. logwood liquor at 10° Tw., 1 qt. bark liquor at 13° Tw., 3 lb. starch. Boil; when cooled down to 110° F. (43° C.), add further 1 pint oxymuriate of tin at 100° Tw., ½ pint nitrate of copper at 80° Tw., and 1 pint olive-oil.

Green.—Mix the blue and yellow colours here given, according to shade.

Pink.—(1) 1 gal. sapan liquor at 14° Tw., ½ lb. sal-ammoniac, 1 gal. gum water at 6 lb. per gal., 1 pint oxymuriate of tin at 120° Tw.

(2) Special, for blocking in madder work.—4½ gal. sapan liquor at 10° Tw., 9 lb. pink salt (i.e. double chloride of tin and ammonium), 3 lb. sal-ammoniac, 2 lb. blue-stone, 5¼ oz. oxalic acid, 1 pint water, 4½ gal. gum senegal water (6 lb. per gal.), 1⅓ qt. oxymuriate of tin at 120° Tw.

Purple.—1 gal. logwood liquor at 8° Tw., 1 gal. water, 10 oz. copperas, 2 lb. starch. Boil, and add 1 pint protochloride of iron at 80° Tw., 1 pint oxymuriate of tin at 120° Tw.

Red.—3 gal. sapan liquor at 4° Tw., 1 lb. sal-ammoniac, 1 lb. verdigris, 4½ lb. starch. Boil, and add when cold, 5 lb. pink salt, 1 lb. oxalic acid.

Yellow.—1 gal. berry liquor at 10° Tw., 8 oz. alum, 1 lb. starch. Boil, and add 1 pint double muriate of tin at 120° Tw.

Such of the coal-tar colours as can bear the presence of acids, e.g. acid rubine, may, if desired, be applied in spirit styles.

STEAM COLOURS.—This style includes the processes by which the aniline colours in the majority of cases are fixed upon cotton goods, and, in addition, the topical application of the artificial alizarine colours; also printing upon woollen, worsted, and silk tissues, as well as upon mixed fabrics, such as delaines, coburgs, etc. The aim of steaming is to get a moist heat, both the temperature and the degree of moisture being carefully regulated, according to the class of the goods, the nature of the colours, etc. In some cases, the pieces after printing are exposed to the air, at common temperatures, for 12 to 24 hours before steaming; whilst in others, they are steamed immediately. Sometimes, the goods are steamed for a time, taken out to air, and steamed again; whilst on other occasions, the steaming is conducted for the necessary time without interruption. The temperature, the pressure, and the degree of moisture, vary greatly, some printers using very dry, and others very moist, steam.

Before the colours are printed on, the calicoes are generally "prepared" by the following process: The pieces are padded in a solution of stannate of soda, commonly known as "alkaline preparing salts," at 10° Tw., in a machine fitted with wooden rollers. The padding is generally done twice, and in the meantime, the pieces are allowed to remain wet for about 1 hour; next they pass through sours (i.e. dilute sulphuric acid at 1½° to 3° Tw.), then into pure water, and are washed, so that no free sulphuric acid may remain upon them; but the washing must not be so severe as to remove the oxide of tin which has been deposited upon the fibre. The pieces are then drained in the centrifugal machine, carefully dried at a gentle steam-heat, and are ready for printing. For heavy shades, the strength of the solution of stannate may be raised to 24° Tw.; the pieces are left to lie wet for 2 hours, and are then taken through sours at 6° Tw., washed, and drained in the centrifugal. All these operations are repeated once more in the same order, and the goods are then dried. Care must of course be taken to keep the sours up to the same point of acidity. Without attention to this point, they become rapidly weakened, and the fixation of the tin being thus rendered irregular, the colour subsequently produced will be uneven. Preparation with stannate of soda is useful for calico, and is in general absolutely necessary for worsted stuffs, and mixed goods.

The following are examples of steam colours :—

Amber.—15 lb. gum substitute, ⅜ pint neutral olive-oil, 3 gal. bark liquor at 12° Tw., 2¼ pints sapan liquor at 8° Tw., 3 qt. red liquor at 16° Tw. Half boil, and add 6 oz. tin crystals, previously dissolved in 2 pints of the red liquor. Mix, and add $\frac{3}{16}$ pint oxymuriate of tin at 120° Tw. Mix well, and strain as fine as possible.

Blacks.—(1) Machine work.—1 gal. logwood liquor at 6° Tw., 1¼ lb. starch ; boil, and add whilst still hot, 5 oz. copperas ; stir thoroughly, and when the mixture has grown almost cold, add 2 oz. gallipoli oil, and 10 oz. nitrate of iron, well neutralised.

(2) 1 gal. logwood liquor 12° Tw., 1 qt. gall liquor 9° Tw., 1 qt. mordant, 2 lb. flour, 6 oz. starch. For the mordant, mix 1 qt. acetic acid, 1½ qt. acetate of copper, 1½ qt. black liquor 24° Tw., 1 qt. red liquor 20° Tw.

(3) For calico.—Dissolve in water 5 lb. 7 oz. solid French extract of logwood, and allow the liquor to settle. Dissolve separately in water 17¼ oz. gum tragacanth. Mix the two solutions, and boil. Boil out 2 lb. 3 oz. gall-nuts in water, and add the decoction to the above, making up to 17½ pints. Let cool, and stir in 2 lb. 3 oz. nitrate of iron at 30½° Tw., and the same weight of black liquor at 26¾° Tw. Print, and hang up for two days, or preferably for a few hours ; steam well, and wash.

(4) For printing cotton yarns.—Dissolve in water 5 lb. 7 oz. solid French extract of logwood, and 17¼ oz. gum tragacanth. Make up the mixed solution to 21 pints, in which dissolve 4½ oz. extract of bark. Let cool and stir into the mixture 2 lb. 3 oz. black liquor at 30½° Tw., and 17 oz. nitrate of iron at 98° Tw. Print, hang up for 2 days, steam, and wash. If a blue tone is required, the nitrate of iron is left out.

Blues.—(1) Dark, for cylinder work. —7 gal. water, 11 lb. starch, 2¾ lb. sal-ammoniac ; boil, and add, while hot, 12 lb. yellow prussiate, ground, 6 lb. red prussiate, 6 lb. tartaric acid. When nearly cold, add 1 lb. sulphuric acid at full strength, 2 lb. oxalic acid (previously dissolved in 2 lb. hot water), 6 gal. tin pulp. Tin pulp is prepared as follows : The strongest double muriate of tin, a saturated solution of the protochloride of tin (stannous chloride) is mixed up with as much solution of yellow prussiate as will throw down all the tin as a ferrocyanide. Wash in water by decantation, and drain on a filter till it becomes a stiff paste.

(2) Aniline.—35 fl. oz. red liquor at 20¼° Tw., 35 fl. oz. bisulphite of soda at 39½° Tw., 3½ pints strong gum water, 3½ oz. aniline blue (Schlumberger, Brussels). The colour, when ready, is printed at once. The calico may either be printed without any preparation or it may be padded in a soap-lye containing 1 oz. curd-soap per pint, and dried. After printing, steam for 1½ hour. Wash, take through lukewarm soap-lye, and sour in weak muriatic acid. Wash, and dry.

(3) Prussian blue for shawls, etc.—Boil up 10 oz. starch to a uniform paste with 7 pints water ; stir into it 2½ lb. yellow prussiate, 1½ lb. red prussiate, 7 lb. tin pulp, 4 lb. tartaric acid, ¼ lb. oxalic acid, 5½ pints water, and 1 oz. sulphuric acid.

Browns.—(1) Catechu.—Boil 4 lb. catechu in water ; let settle, and strain off the clear. The liquor thus obtained is mixed with 1 lb. red liquor at 8¼°

Tw. ; and thickened with ¾ lb. gum tragacanth.

(2) Dark.—6 lb. starch gum, 9 lb. satin gum, 2 pints olive-oil, 16½ qt. red liquor at 17° Tw., 6 pints acetic acid at 7° Tw., 4 gal. catechu liquor, 4 lb. sal-ammoniac, 4 qt. sapan liquor at 8° Tw., 4 qt. logwood liquor at 10° Tw., 1 qt. acetate of copper, 1 qt. nitrate of copper at 86° Tw. Boil well, and strain.

(3) Bimas.—336 oz. extract of bimas at 5½° Tw., 56 oz. acetic acid at 11¼° Tw., 56 oz. cubic catechu, 14 oz. sal-ammoniac, 10 oz. verdigris. Thicken with 200 oz. gum arabic.

(4) Berry.—1½ gal. berry liquor at 20° Tw., 1½ gal. Brazil-wood liquor at 8° Tw., 3 lb. alum, ¾ gal. lavender liquor, 1½ gal. gum senegal water at 6 lb. to the gal., 1½ lb. nitrate of copper at 100° Tw.

(5) Standard.—3½ gal. bark liquor 12° Tw., 3½ qt. sapan liquor 12° Tw., 1½ qt. logwood liquor 12° Tw., 3 gal. gum substitute water 8 lb. to the gal., 3½ lb. alum, 2 oz. chloride of potash, 5 oz. red prussiate. Light browns are obtained by letting this standard down with gum water.

(6) 3 gal. bark liquor 12° Tw., 3 gal. berry liquor 12° Tw., 2 gal. logwood liquor 12° Tw., 2 gal. sapan liquor 10° Tw., 48 lb. British gum. Boil, and add 3 lb. alum, 2 lb. sal-ammoniac, 2 lb. sulphate of copper (blue-stone), 2 pints nitrate of copper 8° Tw., 3 gal. lilac standard. To prepare the lilac standard, take 4 lb. gum senegal, 8 oz. red prussiate of potash, 12 oz. alum, 1 oz. oxalic acid, 2 oz. binoxalate of potash (salt of sorrel). Dissolve in 1 gal. logwood liquor 20° Tw., previously heated to 173° F. (79° C.).

(7) 1 gal. berry liquor 3° Tw., ¼ pint logwood liquor 8° Tw., ½ gal. peachwood liquor 8° Tw., 24 oz. solid nitrate of copper, 24 oz. alum. Thicken according to shade with gum senegal water.

Buff.—1 gal. bark liquor 10° Tw., 3 gal. madder liquor, ½ gal. red liquor 14° Tw., 7 lb. starch. Boil, and add 2 oz. crystals of tin.

Chocolates.—(1) Cylinder work.—2 gal. sapan liquor 12° Tw., 3 gal. logwood liquor 12° Tw., ½ gal. bark liquor 12° Tw., 1 gal. nitrate of alumina, 4 gal. water, 17 lb. starch. Boil, and add 2½ lb. red prussiate of potash, 8 oz. chloride of potash. To prepare the nitrate of alumina, take 4 gal. boiling water, 12 lb. crystal nitrate of lead, 12 lb. alum, 2½ lb. carbonate of soda crystals. Stir till perfectly dissolved, let settle, and decant the clear.

(2) Alizarine.—2 lb. alizarine paste 15 per cent., 2½ gal. thickening, 1⅘ lb. nitrate of alumina 26¾° Tw., ⅘ lb. acetate of alumina 18¾° Tw., ⅘ lb. red prussiate of potash in hot water, 1 lb. acetate of lime 26¾° Tw. In order to obtain a yellowish chocolate, add, for each qt. 1 oz. extract of bark at 30½° Tw. This chocolate may also be prepared from stale red colours by adding to them for each quart, ⅘ to 1 oz. red prussiate of potash dissolved in hot water.

(3) Chromium. — Take 70 fl. oz. Pernod's extract of madder in paste, 70 fl. oz. acetic acid at 9½° Tw., and 105 fl. oz. acetate of chromium at 25¼° Tw. Mix well, print, and steam. In place of Pernod's extract, a proportionally smaller quantity of alizarine may be used.

(4) 12 qt. sapan liquor at 2° Tw., 3 qt. nitrate of alumina, 6 qt. logwood liquor at 12° Tw., 6 oz. yellow prussiate, 6 oz. red prussiate, 9 lb. chlorate of potash.

Cinnamon.—1 qt. cochineal liquor at 8° Tw., 1 qt. logwood liquor at 8° Tw., 1 qt. berry liquor at 10° Tw., 6 oz. alum, 4 oz. cream of tartar, ½ lb. starch. Boil, and while still warm, add 3 oz. tin crystals.

Drab.—(1) 2 gal. lavender liquor, 2 gal. blue standard, 2 qt. bark liquor 8° Tw., 20 to 35 gal. gum water. To make the blue standard, take 2 gal. water, 4 lb. yellow prussiate, ¾ lb. alum, 1½ lb. sulphuric acid 170° Tw.

(2) Dark.—4 qt. berry liquor at 12° Tw., 7 lb. gum substitute. Boil, cool, and add 24 oz. alum, 16 oz. copperas, 1 qt. logwood liquor at 2° Tw., 1 qt. cochineal liquor at 3° Tw.

Greens.—(1) 7 pints berry liquor at 11¼° Tw., 1¾ pint red liquor at 11¼° Tw., 7 pints blue mixture. When cold, add 8¾ oz. solution of chloride of tin at 113½° Tw., 20 oz. white starch. Steam twice for 20 minutes each time; wash, dry, and finish with 350 pints cold water, 88 lb. white starch, and 4 lb. 6 oz. stearine. To make the blue mixture, dissolve 22 lb. yellow prussiate, 3¼ lb. tartaric acid, and 3¼ lb. oxalic acid in 87½ pints boiling water.

(2) Cæruleine.—17½ qt. gum water, 7 qt. cæruleine, 1¾ pint bisulphite of soda. To be added on using, 3½ pints acetate of chrome at 26¾° Tw.

(3) Bark.— 2¼ lb. starch, 1½ gal. bark liquor at 16° Tw. Boil, and add 9 oz. alum, 1½ oz. oxalic acid, 8 oz. tin crystals. When half cold, add 1 lb. 14 oz. tartaric acid, 3 lb. 6 oz. yellow prussiate, 1½ pint tin pulp, ⅜ pint olive oil. After steaming, pass through chrome liquor at 4½° Tw. Wash in clear water, and dry.

(4) Aloes.—Chrysammide (the product of chrysammic acid on treatment with ammonia), thickened according to shade with gum water. After steaming, this colour comes up a rich moss green, which is not affected by boiling water, nor by the madder baths, and is capable consequently of a variety of useful applications. Thus an aloes green ground may be obtained; iron and alum mordants may be printed on, and the piece may be dyed with alizarine, giving red, purple, chocolate, and black figures on a green ground.

(5) For block grounds.—4 gal. bark liquor at 10° Tw. boiled up with 6 lb. starch. Add 2½ lb. alum, 3 lb. tartaric acid, 6 lb. yellow prussiate of potash, 12 oz. oxalic acid, and ¼ gal. tin pulp. After printing, take through a weak bath of bichromate of potash, to raise the colour.

(6) For block work.—14 lb. yellow prussiate, dissolved in 3 gal. very hot water. Mix meantime, in another vessel, 1 gal. water, ½ gal. double muriate of tin at 120° Tw., and 5 gal. gum senegal water at 6 lb. per gal. Now mix these two liquids by pouring them repeatedly backwards and forwards, and stirring thoroughly. When perfectly mixed, add 6 gal. berry liquor at 10° Tw., 5 lb. tartaric acid, 1¼ lb. oxalic acid, previously dissolved in 2½ gal. water, 1½ qt. acetic acid. $\frac{9}{16}$ pint extract of indigo.

Greys.—(1) Aniline for Calico. —Dissolve 21⅝ oz. chlorate of potash in 6 pints boiling water. When cold, add 11¾ pints gum water, 10⅞ oz. sal-ammoniac, 3¼ lb. chromo-tartrate of potash at 49° Tw., 6⅞ oz. aniline, and 2 lb. 8½ oz. tartaric acid. Print on, age for 48 hours at 89° F. (32° C.), and wash for 1 hour. Lighter shades are produced by increasing the gum. This grey gives a fine ground, and can be submitted to all the operations necessary for alizarine reds, except passing through a salt of tin. To prepare the chromo-tartrate of potash, 33⅛ oz. bichrome are dissolved in 5½ pints boiling water. When it has cooled down to 110° F. (43° C.), add gradually 3 lb. 2⅛ oz. tartaric acid in fine powder, avoiding a rise of the temperature.

(2) Uranium Madder. — Add together 70 fl. oz. extract of madder in paste, 70 fl. oz. acetic acid at 9½° Tw., and 135 fl. oz. acetate of uranium at 14° Tw.

Lavender.—4 gal. lavender liquid, 4 gal. blue standard, 24 to 48 gal. gum water. The lavender liquid is prepared by mixing 2 gal. red liquor at 18° Tw. with 6 lb. ground logwood. Steep for 48 hours, and strain off the clear. A stronger quality is made from 10 lb. logwood with the same quantity of red liquor. For blue standard, take 1 gal. water, ¾ lb. oxalic acid, 4½ oz. yellow prussiate, 28 oz. gum substitute.

Lilac.—6 gal. pink standard, 2 gal. purple standard, 20 lb. gum substitute. For pink standard, mix 4 gal. cochineal liquor at 6° Tw., 2 lb. alum, 2 lb. cream of tartar, ½ lb. oxalic acid. For purple standard, 2 gal. logwood liquor at 12° Tw., 12 oz. alum, 8 oz. red prussiate, and 4 oz. oxalic acid.

Orange.—Mix 9 lb. 13 oz. saturn red

(Baden Aniline and Soda Co.), 7 fl. oz. glycerine-arsenic, 44 fl. oz. water, 10½ pints blood-albumen thickening, 3½ pints gum water. The gum water is made by dissolving 21¾ oz. gum senegal in 1¾ pint water. For the glycerine-arsenic, dissolve 2 lb. 8¾ oz. arsenious acid in 17½ pints glycerine at 36° Tw., and concentrate to 100° Tw. To make the blood-albumen thickening, dissolve 13 lb. 2 oz. blood-albumen at a gentle heat in 16 pints water, 7 fl. oz. caustic ammonia at 10 per cent., and 8½ fl. oz. oil of turpentine. Print, dry, steam, and wash.

Pinks.—(1) Sapan-wood.—1 gal. sapan liquor at 3° Tw., 1 lb. pink salt, ½ lb. sal-ammoniac, 1 oz. oxalic acid, 1 oz. blue-stone, 1 gal. thick gum water.

(2) Standard (Cochineal).—4 gal. cochineal liquor at 6° Tw., 2 lb. alum, 2 lb. bitartrate of potash (cream of tartar), ½ lb. oxalic acid, 4 gal. thick gum senegal water.

(3) Mixed.—5 gal. sapan liquor at 8° Tw., 1 gal. cochineal liquor at 8° Tw., ½ lb. nitrate of alumina, 3 lb. alum, 2 oz. oxalic acid, 8 oz. chlorate of potash. When these ingredients are perfectly mixed up, add 12 gal. gum water.

(4) Cochineal.—1 gal. cochineal liquor, 8° Tw., 20 oz. starch. Boil a little, and add 3 oz. oxalic acid. Dissolve, strain, print, steam for 40 minutes at 3 lb. pressure; let lie for a night, and run through very weak alum-water.

Purples.—(1) Alizarine.—1⅘ lb. alizarine paste 15 per cent., 2½ gal. thickening for purple, ⅗ lb. pyrolignite of iron, 17° Tw., ¾ lb. acetate of lime, 23½° Tw. After printing, the pieces are steamed for 1 to 2 hours at a pressure of ½ atmos., and then aged for 24 to 36 hours. The steam should be very moist. The pieces are gathered on rollers, and rinsed for 1 to 1½ hour through the following baths, heated to 122° to 140° F. (50° to 60° C.): 250 gal. water, 40 lb. chalk, 10 lb. arseniate of soda. Wash, soap for ½ hour in a bath containing 2 lb. soap to 10 pieces of 50 yd. each, heated to 140° to 160° F. (60° to 71° C.). Wash; dry; if needful, give another light soaping. The best results are obtained by steaming perfectly dry pieces with wet steam. The thickening for purples, above mentioned, consists of 12 lb. wheat starch, 4½ gal. water, 2¼ gal. tragacanth mucilage, 3 qt. acetic acid 11·2° Tw., 2 lb. olive-oil.

It is to be remarked that alizarine shades, when obtained by dyeing upon mordants previously printed upon the fibre, are more beautiful, more transparent, faster, and more economical than when fixed by steaming. Hence alizarine colours ought not to be applied by steaming, except when it is absolutely necessary, i.e. when blues, greens, yellows, oranges, catechu browns, greys, mauves, etc., have to be associated with alizarine reds and purples.

(2) Logwood.—1½ gal. logwood liquor at 16° Tw., 1½ gal. red liquor at 20° Tw., 1 oz. carbonate of soda, 5 oz. crystal soda, 5 oz. red prussiate, ¾ lb. oxalic acid, 10 lb. gum senegal. Boil, cool, and strain.

Reds or Roses.—(1) Magenta.—¼ oz. magenta crystals, 6½ oz. acetic acid, 3 oz. water. Dissolve at a boil. Meantime mix for thickening 17½ fl. oz. red liquor at 21¾° Tw., 17½ fl. oz. water, and 12 oz. dextrine. Boil, cool and mix with 4½ oz. thick gum water.

(2) ½ to ¾ oz. magenta crystals, ¼ lb. alcohol, 10 oz. boiling water. Dissolve, and add ¼ oz. oxalic acid. Thickening: 17½ oz. thick gum water, 18 oz. decoction of galls at 11¼° Tw., 9 oz. acetic acid. Mix, and add to the red; and stir in further 17½ oz. thin gum water.

(3) 1¾ pint red liquor at 14° Tw., 2¾ oz. arsenite of soda, and ⅝ oz. magenta. Steam for 1 hour, soap, and wash in pure water. This process is applicable also to other aniline colours.

(4) Aniline rose.—35 oz. water, 6 oz. starch, 35 fl. oz. red liquor. Dissolve, and stir in 7½ oz. roseine carmine (Baden Aniline Works).

(5) Saffranine for calico.—Mix ½ pint saffranine paste with 10 pints of the subjoined thickening: 1 gal. acetate of alumina (red liquor) standard, 1 gal. water, and 2 lb. starch. Boil, cool, and add 1 pint arsenic and glycerine stan-

dard. The acetate of alumina standard is made with 1 gal. boiling water, and 2½ lb. alum. Dissolve, and add 3 lb. white acetate of lead. Dissolve, let settle, and use the clear. The arsenic-glycerine standard is composed of 1 gal. white glycerine, 4 lb. arsenious acid; boil till dissolved, and filter. Print the colour on, and steam for ½ hour.

(6) Dissolve ¼ oz. saffranine in 3½ oz. hot water. Make prepared thickening: 2 lb. 3 oz. acetate of alumina at 21¾° Tw., 17½ oz. arsenite of soda at 98° Tw., 1 lb. 10 oz. acetic acid. Mix; dissolve separately 2 lb. 3 oz. soda, and the same weight of white arsenic in 2⅗ pints of water. Mix all together, and 3 lb. 4 oz. gum water at 2 lb. 3 oz. per 1¾ pint. Take 5 lb. 7½ oz. of the thickened, and 1 lb. 1½ oz. solution of saffranine. Steam as in the former process. This colour is applicable for mixed goods.

(7) Eosine.—Print with a thickened solution of eosine; steam, and pass into a bath of acetate of lead.

(8) Animalise with albumen, and dye in solution of eosine.

(9) Thicken a solution of eosine with white starch, or gum tragacanth; add arsenite of alumina (i. e. mixture of arsenite of soda and red liquor as given under saffranine). Print upon cloth prepared with tin; steam, and wash.

(10) Mix a solution of eosine with acetate of lead, acetate of tin, or red liquor thickened. Print upon calico, prepared with tin or oiled; steam, and wash. Upon oiled calico the shades are bluish.

(11) Prepare the calico with solution of glue; print on a mixture of eosine with 3 times its weight of tannin; steam, and wash.

(12) Grain Ponceau.—Boil 17½ oz. cochineal in 10½ pints water. Boil out the residue again in water; mix the decoctions, and evaporate down to 10½ pints; let cool, and settle. In the clear liquid, dissolve 6¼ oz. oxalic acid, 3½ oz. white starch, and 4¾ oz. white glue. Print, steam at 190° F. (88° C.), and rinse.

(13) Grain Red for Mixed Silk and Cotton Goods.—Mix 1 oz. extract of cochineal at 6·8° Tw. (for heavy shades this may be doubled), with the same quantity of berry liquor at the same strength. Thicken with 17½ oz. gum tragacanth; boil, stir till cold; dissolve in the liquid, 8⅗ oz. oxalic acid, and 3⅕ oz. tin crystals. Make up to 17½ pints. Print, dry, hang up for 24 hours, steam for 1 hour at 212° F. (100° C.), and rinse.

(14) Alizarine Red for Grounds.—1⅗ lb. alizarine paste, 15 per cent. (if 10 per cent. 2 lb.); 1 qt. acetic acid at 8·2° Tw., 2 qt. water, ⅗ lb. olive-oil, ⅗ lb. acetate of lime at 14° Tw., 1 lb. wheat starch. Boil the whole, stir well till cold, and add ⅗ lb. acetate of alumina.

(15) Ditto for Mille Fleurs.—5⅕ lb. alizarine paste, 15 per cent.; 10 qt. thickening for reds, ⅗ lb. nitrate of alumina at 21¾° Tw., 1⅕ lb. acetate of alumina at 17° Tw., ⅘ lb. acetate of lime at 23½° Tw.

(16) Ditto for very deep Reds.—6⅗ lb. alizarine paste, 15 per cent.; 10 qt. thickening for reds, ⅘ lb. nitrate of alumina at 21¾° Tw., 1⅕ lb. acetate of alumina, at 17° Tw., 1 lb. acetate of lime at 23½° Tw.

(17) Red without Olive-Oil.—5⅗ lb. alizarine paste, 15 per cent.; 9⅗ lb. acetic acid at 11·2° Tw., 3⅗ lb. flour, ⅘ lb. water. Boil to a paste, stir till cold, and then add 5½ oz. acetate of lime, at 23½° Tw., 2 lb. nitrate of alumina at 21¾° Tw., 3 lb. hyposulphite of lime at 12·6° Tw.

(18) Red and Pink.—3⅕ lb. alizarine paste, 15 per cent.; 8 qt. thickening for red, 1 lb. acetate of alumina, 17° Tw.; ½ lb. acetate of lime, 23½° Tw. For pink, add 2 to 3 times its weight of thickening for red.

If a dark-red design is to be covered by a lighter red, the dark red is first steamed for 1 hour. After printing the second colour, it is again steamed for 1 hour, and hung up for 24 hours. The pieces are then taken through either of the two following baths: (*a*) 250 gal. water, 60 lb. chalk, 3 lb. tin crystals. (*b*) 250 gal. water, 40 lb.

chalk, 10 lb. arseniate of soda. The baths are heated to 122° to 143° F. (50° to 62° C.), and the passage lasts for 1 to 1½ minute. Wash, and rinse in the following soap becks, each warmer than the former, and prepared as follows (for 10 pieces of about 50 yd. each): First beck: 3 lb. soap, ¼ lb. tin crystals; heat 122° F. (50° C.); time, ½ hour. Second beck: 3 lb. soap; heat, 167° F. (75° C.); time, ½ hour. Third beck: 3 lb. soap; heat, 167° to 177° F. (75° to 80° C.); time, ¼ hour. After each soap bath, the pieces are well washed.

The Thickenings and Mordants here mentioned, are prepared as follows:—

Thickenings for reds, No. 1.—12 lb. wheat starch, 7 gal. water, 1 gal. acetic acid, 8·2° Tw., 2¼ gal. tragacanth solution (2 oz. per qt.), 3 lb. olive-oil, which must be thoroughly incorporated with the mass. Stir till perfectly cold.

No. 2.—12 lb. wheat starch, 4½ gal. water, 4¼ gal. acetic acid, 8·2° Tw., 3 lb. olive-oil.

Nitrate of Alumina Mordant.—20 lb. nitrate of lead, 20 lb. alum, 5 gal. boiling water. Let the sulphate of lead settle, and draw off the clear. If the nitrate of alumina is used instead of the acetate, it causes the red to turn more to a scarlet; but it requires the use of a little more acetate of lime than acetate of alumina.

Acetate of Alumina Mordants.—Dissolve first 68 lb. alum in 100 gal. water, and precipitate by adding a solution of 62 lb. soda crystals in 150 gal. water. This precipitate, which is a basic sulphate of alumina, is washed 3 times by decantation. It is then thrown on a filter, let drain, and pressed. Of the paste thus obtained, 30 lb. are placed in 6 qt. acetic acid at 11·2° Tw., and heated to 90° F. (32° C.), till complete solution has taken place. It is then filtered, and diluted with water to the strength required. As a general rule, 100 parts alizarine paste at 15 per cent. require 30 acetate alumina at 17° Tw.

Acetate of Lime Mordant.—The solution of acetate of lime at 32½° Tw. contains about 25 per cent. of the salt. For a neutral well-washed paste, at 15 per cent., about 15 per cent. of its weight of acetate of lime is used.

Alizarine reds produced by printing are never quite so beautiful as the corresponding shades obtained by dyeing upon mordants according to the madder style.

Violets.—(1) Galleine.—35 qt. galleine paste, 17½ qt. gum water, 1¾ qt. acetate of chrome at 26¾° Tw. Print, and steam.

(2) Hofmann's.—Mix the dissolved and filtered colour with red liquor, and with a solution of arsenious acid in glycerine. Thicken with gum and starch. Steam for 1 hour, and soap gently.

(3) Aniline.—½ oz. Hofmann's or Perkin's violet, 13½ oz. hot alcohol. (There are now violets perfectly soluble in water.) Dissolve, filter, and add immediately 1½ oz. tannin, ¼ oz. oxalic acid. Let cool, and meantime mix 2½ lb. thick gum water, 18 oz. water, 18 oz. acetic acid. Stir up well, and add to the above solution of colour. Print, and steam.

(4) 17½ oz. pure tannin are dissolved in 15¾ pints gum water, and an amount of aniline violet is added according to the required shade. Print, steam, enter the pieces at 135° to 180° F. (57° to 82° C.) into a bath of tartar emetic, containing ½ oz. of this salt per 1¾ pint; wash, and dry. Or the pattern may be printed on with a thickened solution of tannin, ranging from ¾ oz. per 1¾ pint for pale, to 4½ oz. for full shades, steamed, and passed into a bath of tartar emetic. They are then well washed and dyed in the bath of aniline violet, raising the temperature gradually to a boil, which is kept up for 20 minutes. Wash, and soap slightly. This process is applicable to various other aniline colours.

Yellow.—4 gal. berry liquor at 12° Tw., 1½ lb. alum.

Dyeing Wool.—*Amaranth.*—On

Yarns and Pieces. Boil 87 dr. orchil in water, and make up the decoction to 1¾ pint. Boil 30 dr. cochineal in water, and make up the decoction to 1 pint. Thicken the mixture with ½ lb. starch. Stir till cold, and add, whilst constantly stirring, 25 dr. ground alum, 12½ dr. perchloride of tin. When thoroughly mixed together, print, steam, and rinse.

Black.—On 50 lb. Flocks, resisting the fulling mill.—20 lb. logwood, 7 lb. yellow-wood, 6 lb. sumach, 2½ lb. tartar. Boil the wool in this bath for 2 hours, then replace the evaporated water, and wet the wool, continually shaking it, with the solution of 2½ lb. sulphate of iron, 1½ lb. sulphate of copper. Boil for an hour. For a bluish black, wet the wool as above, as soon as it is lukewarm, with 2 lb. sal-ammoniac, and then rinse, and dry it well. For a deep black, substitute for sal-ammoniac 1½ lb. bichromate of potash, dissolve it in boiling water, and boil for ¼ hour.

Blue.—(1) Woad on yarn (10 lb.).—Boil ½ hour with 167 dr. alum., 80 dr. argol, 50 dr. extract of indigo. Take out, let half the contents of the pan run off, fill up with cold water, and dye at 122° F. (50° C.) with 2 to 3 lb. logwood.

(2) On 15 lb. Wool spun for Knitting.—Mordant by boiling 1 hour in a bath containing 1 lb. alum, 1 lb. tartar, ½ lb. indigo carmine, 2½ oz. tin salt. Take out the wool, and let half the bath flow away, replacing by cold water. Dye at 112° F. (50° C.) with 2½ lb. logwood.

(3) Deep Blue on 50 lb. Flocks of Wool, resisting the fulling mill.—Give a ground of blue, rinse in hot water, and mordant for an hour in a boiling bath containing ½ lb. bichromate of potash, 5 lb. alum, ¼ lb. copper, 2½ oz. tin salt; then dye with the addition of ¼ lb. sulphuric acid, rinse, and dry.

(4) Logwood Blue.—Wool can be dyed with logwood or false blue by several processes which recommend themselves by their cheapness and simplicity. Old dyers used to dye in a single bath, whilst nowadays the process consists of one mordanting either at cold or hot, and to dye in a solution of the dyeing matter. The colour is fixed on the wool by means of different salts with which it is impregnated before dyeing, and which render the colouring matter insoluble in water when fixed on the fibre. The two following processes are in use in Aix-la-Chapelle :—

(*a*) Middle Blue on 100 lb. Wool.—Boil for 2 hours in water : sulphate of soda, 10 lb. ; tartar, 6 lb. ; tin crystals, 3 oz. ; sulphuric acid, 8 oz. Leave the wool during the night, then dye with logwood, 40 lb. ; carbonate of soda, 1 lb.

(*b*) Violet Blue on 100 lb. Wool.—Boil for 1½ hour with sulphate of soda, 8 lb. ; tin crystals, 2 lb. ; tartar, 4 lb. Then dye with logwood, 30 lb. ; orchil, 5 lb. ; sulphate of copper, 4 lb.

(5) Pensée.—4 lb. orchil 13° B. (brand B), 12 oz. gum senegal.

(6) Mode.—4 lb. cachou extract 2° B., 2½ oz. ammoniacal cochineal, 2½ oz. indigo acetate ; thicken with 8 lb. of the thickening given in grey (1).

(7) Mode.—2 lb. cachou extract, 2° B. ; heat and pour over 12 oz. gum senegal, 1½ oz. alum, ¾ oz. tartaric acid.

Green.—(1) Solid Green on 100 lb., Wool.—Dye in the following bath : alum, 15 lb. ; sulphuric acid, 5 lb. ; sulphate of indigo, 5 lb. ; picroline, 12 oz.

(2) Fresh Green on 100 lb. Wool.—Dye bath : sulphate of soda, 12½ lb. ; sulphuric acid, 7½ lb. ; carmine of indigo, 7½ lb. ; picroline, 1 lb.

(3) Vert possé (fast green) on 25 lb. Wool.—Glauber salt, 1½ lb. ; sulphate of alumina, 1½ lb. ; sulphate of indigo, 1 lb. ; orchil, 1 lb. ; turmeric, 4 lb. Boil in this bath for 1½ hour.

(4) Feuille morte (dead leaf) on 25 lb. Wool.—Sulphate of alumina, 1½ lb. ; sulphate of soda, 1½ lb. ; sulphate of indigo, 1 lb. ; orchil 3 lb., or orchil extract, 1 lb. ; turmeric, 2 lb. Boil in this bath for 1½ hour.

(5) Feuille sèche (dried leaf), on

25 lb. Wool.—Sulphate of soda, 1½ lb. ; sulphate of alumina, 1½ lb. ; sulphate of indigo, ½ lb. ; orchil, 3 lb., or orchil extract, 1 lb. ; turmeric, 1½ lb. Boil in this bath for 1½ hour.

(6) 14½ oz. white starch, 2½ lb. water, 9 lb. Cuba lac ; boil ; add when warm, 5 oz. indigo carmine ; mix well ; decant the colour ; add whilst tepid, 5 oz. oxalic acid ; and when cold, 7½ oz. alumina sulphate.

(7) 2 lb. malachite green solution, 5 per cent. ; 2 lb. gum substitute water, 65 per cent.

Grenade.—(1) Steam Grenade (fast). —Colour : orchil, 14° B., 6 lb. 4 oz. ; extract quercitron, 20° B., 8 oz. ; gum thickening, 1 lb. 8 oz. After boiling, add : alum, 3 oz. ; tartaric acid, ½ oz. ; indigo carmine, 1½ oz. (2) Bordeaux R.

Grey.—(1) Pearl Grey.— Colour : ammoniacal cochineal, 3° B., 2½ oz. ; acetate of indigo, 10° B., 1½ oz. ; 2 lb. 8 oz. of the following thickening : gum water, 12 lb. ; alum, 12 oz. ; tartaric acid, 1¾ oz. (2) Induline.

Maroon.—On 50 lb. Wool, resisting the fulling mill.—Prepare a dyeing bath as follows : to a clear solution of 10 lb. catechu add 2 lb. logwood and 2½ lb. tartar. Boil the wool for 2 hours in this bath, rinse, and add to the above bath 2 lb. bichromate of potash and 1 lb. sulphate of copper. Put the wool in, and boil for ½ to 1 hour, according to the shade required, and then rinse.

Olive.—(1) On Yarn (10 lb.).—Boil with 96 dr. prepared tartar, 20 dr. blue vitriol, 375 dr. orchil, 50 dr. turmeric, 40 dr. indigo sulphate. Cerise as required.

(2) Fast Light on 100 lb. Yarn.—Half fill the vat with water, bring to boil, and dissolve 2 lb. fast yellow, 4½ oz. fast brown, 7½ oz. light green S., 3 oz. induline, and then 40 lb. tartar composition, 10 lb. Glauber salt. Fill the vat with water, enter yarn, boil 1 hour, wash, and dry. This colour remains olive also by artificial light.

(3) On 15 lb. Wool.—Boil with 1 lb. potash bisulphate, 1¼ oz. copper sulphate, 2½ lb. orchil, ¼ lb. turmeric, ¼ lb. indigo sulphate, and garnet according to shade required.

Orange.—(1) Alizarine on 150 lb. Wool.—Boil for 1¼ to 1½ hour in the following bath, containing : alum, 7½ lb. ; tartar, 12½ lb. ; tin crystals, 2½ oz. ; and alizarine W., 15 lb.

(2) Printing.—Colour : Persian berries decoction, 9° B., 4 lb. ; gum senegal, 1 lb. 2 oz. ; alum, 4 oz. ; tin crystals, 4 oz. ; oxalic acid, 1 oz.

Ponceau.—(1) 1 lb. cochineal decoction, 5° B., 1½ lb. white starch ; boil well ; add when lukewarm, 9 oz. oxalic acid, 1½ oz. tin crystals, 3 oz. double tin chloride. (2) 2 lb. solution of ponceau R., containing 4 per cent., 2 lb. solution of gum substitute, containing 65 per cent.

Puce.—Steam Puce (fast).—Colour : orchil 12° B., 4 lb. 8 oz. Heat and dissolve in it by small quantities, after taking away from the fire : alum, 1 oz. ; tartaric acid, ¼ oz. ; thicken with white starch, 3 oz. ; gum, 2 oz. ; then add indigo carmine, ¼ oz.

Red.—(1) Fire Red on Yarns and piece goods.—5¼ pints cochineal extract at 7° B., 157 dr. starch ; boil well together, and add 12½ dr. oxalic acid. Stir till cold, and add, whilst constantly stirring, 12½ dr. tin crystals, and 25 dr. berry liquor at 7° B. Mix perfectly, print, steam 1 hour, rinse.

(2) Scarlet on 100 lb. Wool.—Dissolve in boiling water : liquid extract of quercitron, 3 lb. 8 oz. ; oxalic acid, 3 lb. 8 oz. ; tin crystals, 1 lb. 12 oz. ; tartar, 4 lb. ; cochineal, 4 lb. ; chloride of tin solution, 8 lb. Mix well when dissolved, add cold water, enter wool, and boil for 1 to 1½ hour.

Violet.—(1) 4 lb. orchil, 13° B. (brand M) ; 12 oz. gum senegal.

(2) Colour : water 10 lb. ; ammoniacal cochineal, 3° B., 20 lb. ; white starch, 3 lb. 8½ oz. ; boil, and add when warm—oxalic acid, 4½ oz. ; alum, 1 lb. 8½ oz. ; deuto-chloride of tin, 1¼ oz.

Wood-colour.—Steam. Colour : orchil, 10° B., 10 lb. ; cambresine decoction, 10° B., 10 lb. Thicken with gum thickening, 4 lb. ; and add, after taking away from the fire—alum, 1 lb. ; oxalic acid, 3¾ oz. ; sulphate of iron, 3¼ oz. The cambresine decoction is obtained by boiling 3 different times—fustic, 2 parts ; Persian berries, 1 part, in water, and mixing together the 3 decoctions, which are then reduced to 10° B.

Dyeing Silk.—In dyeing silk goods with aniline they should be prepared by being washed in a soap liquor which has had its alkalinity slightly soured by the addition of a little sulphuric acid. (This is termed sweetening in the trade.) After dyeing, the goods are commonly rinsed in cold water, slightly acidulated. This acidulation can be done with tartaric, acetic, or citric acids.

Blue.—(1) Aniline Blue dyed with Soap.—For 11 lb. silk add to a water 17¼ oz. sulphuric acid and 3½ oz. solution of white soap. Stir well up, and dye at 158° F. (70° C.) with 1¾ oz. aniline blue, which is added in 4 successive portions. Wash, brighten with vitriol sours, and rinse.

Green.—(1) On Old Mixed Silks (2 lb.).—Boil out 25 dr. sumach in water, strain the liquid, and steep the goods overnight in the clear hot liquid. Take out the next morning, squeeze, and dye in a fresh cold beck of methyl green. If a yellower shade is required, picric acid is added.

Magenta.—(1) On Old Mixed Silks (2 lb.).—Prepare and dye as in green (1), using cold solution of magenta instead of green.

Maroon.—(1) Take the silk through a catechu beck, weight for weight, if a good yield is desired. If a smaller yield is wished, less catechu is taken. Dye at a boil, lift, wring, and pass into a chrome beck at 6¾° to 8¼° Tw., and 77° F. (25° C.). If the shade required is very dark, the heat may be raised a little more. Wash well, make up a beck of fustic, extract of indigo, and orchil ; add a little alum to draw on the fustic, and acidulate slightly with sulphuric acid for the blue. Dye at a boil, adding more of any of the colours as the shade may require.

Pansy.—(1) On Old Mixed Silks (2 lb.).—Prepare as green (1), and dye to shade with a solution of methyl violet.

Scarlet.—(1) Boil for ½ hour 11 lb. ground cochineal ; filter, and set the clear liquor at 4° Tw. Add to the beck about 24 fl. oz. tin solution, and dye. It requires 24 hours to produce the scarlet. After dyeing the silks are left wrapped up for 12 hours, rinsed slightly, brightened with citric acid, and dried. The solution of tin is made of 4 lb. muriatic acid, 2 lb. nitric acid, 5lb. feathered tin, dissolved gradually in the course of a day.

(2) Prepare in stannate of soda at 4° Tw., in the cold ; take through weak vitriol sours, and wash well. Give a second mordant of red liquor at 8¼° Tw., thickened with calcined starch at the rate of 3½ oz. per 35 fl. oz. of the mordant. Dry without rinsing for at least 24 hours ; then rinse and dye with decoction of cochineal. When the colour is as deep as is required, add nitrate of tin to the same beck. This process gives scarlets as fine as (1), and with less loss of colouring matter. The object of the addition of calcined starch is to give the silk more body. In many dyeworks scarlets or silks are grounded with annatto.

Violet.—(1) Aniline Violets. Acidulate the water very slightly with sulphuric acid, and enter the silks. Begin to dye in the cold, adding the colour in small successive portions. Raise the heat gradually up to a boil to level the shade. If the tone is too blue, let the beck cool, and take the silks through again. They are then brightened by one or several successive passages through vitriol sours, and it must be remembered that heat increases the blueness and lessens the redness.

Yellow.—(1) The silk must not be washed, and a red shade is first given with annatto in a soap beck, not too strong. It is then washed and rinsed in the cold with sulphuric acid. The yellow shade is then given with picric acid, and the silk is dried without washing. For a heavier shade the process is the same, but turmeric is used instead of picric acid. The solution of annatto is made by boiling together for ½ hour equal weights of potash and annatto.

Dyeing Straw.—(1) *Black.*—In order to obtain a level colour, a solution of gluten is added to a lye of soda, which is allowed to stand for 24 hours, and filtered. The hats are then steeped for 12 hours in the clear liquid. The straw is thus freed from grease, and the mordants of nitrate, sulphate, or acetate of iron, as well as the decoction of logwood mixed with sumach or galls, is very evenly taken up by the fibre. A slight addition of bichromate of potash improves the tone of the dye, and the goods are finished with gum or gelatine. ('Baden Gewerbezeituna.')

(2) *Aniline Green.*—Straw is placed in boiling water, then well washed with cold water and bleached in a bath containing 20 gr. bleaching powder to 7 or 9 gr. sulphuric acid. It is then thoroughly washed and mordanted with sumach, alum, and tartaric acid (not too dilute a liquor). Finally, it is dyed with aniline green and picric acid until the required shade is obtained, after digesting for some time. ('Musterzeitung.')

Dyeing Straw Plait. *See* "STRAW PLAIT."

Dyeing Kid Gloves. (*And see* "LEATHER DYEING.")—Reimann states that the gloves are stretched over a wooden hand, and the colour is spread upon them with a brush. The following prescriptions are given:—

Black.—The glove is washed in alcohol, and 3 times brushed over with a decoction of logwood, allowing between each brushing 10 minutes for drying; afterwards dipped into solution of iron protosulphate, and then brushed over with warm water. Should the colour not prove sufficiently dark, a decoction of quercitron may be added to the logwood decoction. Instead of the protosulphate, some nitrate of iron may be used. As the leather begins to dry, it is rubbed over with talc powder and some olive-oil, and pressed between flannel. The treatment with talc and oil, is repeated, and the glove then allowed to dry on the stretch-wood.

Brown.—The solution is made up of varying quantities of decoctions of logwood and Guinea-wood. For darkening, a small quantity of iron protosulphate is employed.

Russia-Red.—Decoction of cochineal with a tin salt and some saccharic acid, and, if a dark tint is demanded, addition of some logwood extract.

Grey.—Brushing with decoction of sumach, and subsequent treatment with a feeble solution of iron protosulphate. Addition of logwood and yellow Brazil-wood to the sumach decoction produces a greenish-grey tint.

The aniline colours can be employed without any previous preparation of the leather. The bluish tint so greatly liked in black gloves is obtained by washing the finished article with sal-ammoniac solution. If it is required to keep the seams white, they are covered with flour-paste with which some fat has been admixed. Instead of brushes, one may sometimes use a sponge. ('Ding. Polyt. Journ.')

Kid gloves of good quality, especially when light-coloured, are often thrown away when soiled, and made no further use of. By employing the following simple means, they might easily be dyed violet, black, or yellow, by the owner himself, and made to look almost equal to new: The gloves are first soaked in a little hot water containing dissolved crystals of soda or potash, whichever colour may be desired, and after a 25 minutes' bath they are taken out, washed, rinsed, and wrung. When the gloves are thus cleaned, they are stretched tightly on a block, and the dye applied.

Violet.—According to the tint desired, aniline or orseille violet must be used. Apply a little of the colour by means of a brush or rag dipped in the colouring liquid. Lay on several coats of alum dissolved in water; then dry. Then apply one or two layers of the dye, which must be always hot. The kid is polished, before finally drying, with a pad made of a cork covered with a piece of woollen cloth. This is the best way of regaining the gloss.

Black.—The same means are employed throughout.

Yellow.—This requires a less complicated process—a decoction of Avignon crystals with alum. Apply several layers, and polish the kid in the way indicated above. ('Text. Manuf.')

Simple decoction of onion peel is said to produce upon glove leather an orange-yellow superior in lustre to any other. It is also said to be suitable for mixing with light bark shades, especially willow-bark, and as a yellow for modulating browns. The onion dye is said to fix itself readily, even upon leathers which resist colours, and colours them well and evenly. ('Chem. Rev.')

Glove-kids are dyed in two ways: (1) The skins are plunged into the dye bath; in this way all light colours are ordinarily produced, such as pearl grey, straw yellow, reddish yellow, silver grey, aquamarine, etc. (2) The skins are spread on an inclined or round table of stone or metal, and brushed over on the grained side—first with a mordant, then with a dye liquor, and lastly with a solution of mineral salt. The mordant serves to fix the colour on the surface of the skin, to prevent its striking through, to produce certain modifications of colour, and to enable any parts of the skin which yet contain fat to take colour evenly with the rest. To satisfy these conditions, the composition of the mordant is varied. Bichromate of potash, ammonia, potash, soda, and stale urine are among the most frequently employed, seldom separately, but usually in a mixture containing 2 or more. Dyestuffs of vegetable origin have always held the first place. Those most in use are logwood, Brazil-wood, the two fustics, several species of willow bark and of berries, indigo carmine, and indigo dissolved in sulphuric acid. Aniline colours used alone remained in fashion for a short time only, but are now usefully employed as top colours—namely, brushed in very dilute solution over vegetable colours. In this way particularly graceful shades of green, violet, and marine blue may be produced. After the mordant has been applied once or twice, and the colour 3 to 6 times, a wash containing some metallic salt is generally applied, with the object of either bringing out the special tone required, or of making the colour more lively and permanent. The so-called vitriols are mostly employed — "white vitriol" (zinc sulphate), and occasionally other salts. Before dyeing, the greater part of the flour, salt, and alum must be removed from the skins by washing with tepid water, and therefore they require a second treating with egg yolk and salt. In the case of skins which are dyed by plunging into the dye-vat, this is done after the dyeing is completed; in that of brush dyeing, before the dyeing process. After the dyeing, the skins, if dipped, are wrung out; if brush dyed, sleeked out with a brass plate, to get rid of superfluous water. They are then dried in an airy room. Before staking (stretching), the skins are laid or hung in a damp cellar, or in moist sawdust. They are staked twice—once damp, and once nearly dry. Skins which are much damaged on the grain, or otherwise faulty, are smoothed with lump pumice on the flesh side, either by hand or machine. They are then dyed on this side, mostly by dipping, but occasionally with the brush, in which case the method described is slightly modified. ('Spons' Encyc.')

Feathers.—(1) The feathers should be soaked in solution of ammonium or sodium carbonate, whereby they are rendered less liable to break or bend; after being dyed, they should be dried in a current of warm air. Feathers may be dyed black in the following baths: (*a*) 100 pints water, 1 lb. ignited sodium carbonate; (*b*) ferric nitrate at 70° B.; (*c*) 2 lb. logwood, 2 lb. quercitrine. ½ lb. feathers is digested in *a* at 30°; the feathers are then washed with warm water, and soaked in *b*. After another washing they are boiled in *c*, until of a deep black colour ; they are then dipped in an emulsion formed by agitating oil and potassium carbonate together, and dried by gently swinging them in warm air.

(2) Feathers may be dyed brown by first treating them with catechu and then with potassium chromate ; they can be dyed directly with aniline colours, and can be bronzed by painting with aniline violet dissolved in alcohol at 90 per cent. ('Ding. Polyt. Journ.')

(3) Aniline dyes may be used, dissolved in pure methylic alcohol (not commercial methylated spirits). Single colours or a combination of two colours may be used.

Flowers, Grasses, and Mosses.—Dyeing is especially used for the red Xeranthemum annuum fl. pl., red asters, and all kinds of ornamental grasses. Mix 10 parts fresh water with 1 of good nitric acid, plunge the flowers in, shake off liquid, and hang them up to dry. In this way, Xeranthemums, which should be cut when entirely open, will acquire a beautiful bright red tint ; while grasses only become a little pale red on the tops, but will keep afterwards for many years, and may, if needed, be coloured otherwise at any time. Asters generally, when treated in this way, are not so fine as if dried in sand or smoked with brimstone. To colour flowers and grasses blue, violet, red, scarlet, and orange, use the different kinds of aniline : for yellow use picric acid, and for bright scarlet, use borax. The aniline dye should be dissolved in alcohol before it is fit for use, in which condition it should be kept in well-closed bottles until it is required. It may also be purchased in a dissolved condition of any respectable chemist. To colour by means of aniline, take a porcelain, or any other well-glazed vessel, pour in some boiling water, and add as much dissolved aniline as will nicely colour the water. According to the quantity of aniline used, the colour of the flowers will become more or less bright. After the water has cooled a little, plunge in the flowers or grasses, and keep them in it till they are nicely coloured ; then rinse in cold water, shake off the liquid, and hang them up in the open air to dry. To obtain a fine blue, take aniline bleu de lian, boil the colour with the water for 5 minutes, and then add a few drops of sulphuric acid before using. For violet, use 1 part aniline violet and 1 of aniline bleu de lian ; for red, aniline fuchsin ; for scarlet, 1 part aniline fuchsin and 1 of aniline violet ; for orange, aniline d'orange ; for lemon colour, picric acid, which should be dissolved in boiling water, and then thinned with a little warm water. Dip in the flowers, but do not drain off the liquid. All kinds of ornamental grasses can be thus coloured (especially Stipa pennata and Ammobium alatum), white Xeranthemums, and most other everlasting flower. Immortelles, however, as well as the other kinds of Helichrysums, must be treated differently ; their natural yellow colour must first be extracted by dipping them in boiling soap-water, made with Italian soap, and afterwards dried in an airy, shady place. The flowers generally become closed when thus treated, and should be placed near an oven, and subjected to the influence of a dry heat, when they will soon reopen. This is very important, if they are intended to be coloured ; if not, they will remain fine pure white immortelles. Most immortelles, however, are coloured bright scarlet by means of borax, which gives a beautiful colour ; but it does not keep well, and becomes gradually paler. For this purpose dissolve as much borax in boiling water as will colour it nicely ; when cool, dip the flowers, but do not allow them to remain in after they have taken the colour ; if kept in too long, they will not again open their flowers. The chief point in every mode of colouring immortelles is to place them first in a dry, warm atmosphere, where they will open their flowers well ; and, after colouring, they should again be exposed to heat, by which means they will nearly always re-open. Very nice-looking immortelles are also produced by colouring only the centre of each flower scarlet, which is done very rapidly with borax, by means of a small pencil or a thin wooden splinter, dipped into the colour and afterwards applied to the centre. This is generally done by little children in those establishments in Germany and France which supply the trade with everlasting flowers. Finally, a very cheap and a very good recipe to colour ornamental grass and moss a beautiful green: If a dark green is required, take 2 oz. boiling water, 1 oz. alum, and ½ oz. dissolved indigo carmine; plunge the moss or grass into the mixture, shake off the liquid, and dry in an airy, shady place. In the winter, however, they should be dried by means of fire-heat. If a light green is required, add to the above mixture more or less picric acid, according as a more or less light shade is required. ('Eng. Mech.')

China Grass.—In regard to dyeing, it somewhat resembles Tussore silk, being difficult to colour by the ordinary methods; it is therefore necessary to employ energetic methods, of which the principle consists in a preliminary mordanting of the fibre. For every 10 lb. of grass, use 100 pints water and 1 lb. soda crystals or caustic potash; heat to 176° to 194° F. (80° to 90° C.), work for 20 or 25 minutes, and wash thoroughly. Make a bath of 100 pints water, 1 lb. sulphuric acid; heat to 158° to 176° F. (70° to 80° C.), work for 20 to 25 minutes, and wash immediately. The fibre is then ready to receive ordinary dyes. ('Mon. Teint.')

Hats.—The fulling-stock may be made the vehicle for dyeing or staining all fancy colours, as drabs, beavers, slates, mouse, tan, rosy drabs, and many others. Some makers partially dye, and then complete the staining in the stocks.

Beaver.—(1) Take 1¼ lb. copperas, 1 pint pyrolignite of iron diluted with boiling water, 4 oz. Hofmann's aniline blue, 4 oz. indigo extract (free from vitriol, or this will turn it green), for 1 doz. hats.

(2) For the fulling-stocks, for 24 doz. 3-oz. bodies: 1 lb. common graphite (black-lead), 3 lb. Venetian red, 1 gill indigo extract.

(3) Light: 2 lb. red-lead, 1 oz. indigo extract, 1 lb. common graphite, 2½ lb. terra castle.

Cream colour: For 24 doz. 3-oz. bodies: 2 lb. red-lead, 2 lb. common terra castle, 2 gills indigo extract in liquor, 3 gills orchil.

Fawn colour: 1½ lb. burnt sienna ground fine, ¾ lb. burnt umber, ¼ gill orchil, ¼ gill indigo extract in liquor.

Mouse colour: 3½ lb. common graphite (black-lead), 2½ lb. best terra castle, 2½ gills indigo extract in liquor, 4 gills orchil, 8 oz. red-lead.

An ordinary drab for soft hats: ¾ lb. common graphite, ¾ lb. best ditto, 3 gills orchil, 2 gills indigo extract; put the graphite into a pan, cover with water, and let down with sulphuric acid at 30° Tw.

Slate: 4 lb. common graphite, 4 gills indigo extract, 3½ gills orchil.

Cinnamon: 3½ lb. red-lead, 2½ lb. best terra castle, 2½ oz. picric acid, ½ gill indigo extract, 3 pints orchil. The picric acid is first dissolved in hot water, and the other ingredients are added.

General Hints.—To give the best results in fine fur hats, all the hoods should be shaved on a lathe before proofing. Many of the best makers assert that this class of goods will retain better colours by being mordanted before placing in the logwood bath. ('Spons' Encyclopædia.')

Dye-Soaps.—A combined soap and dye may be made by taking any aniline colour and dissolving it in alcohol and water. Gin is commonly the alcohol used, 4 oz. of this with 4 oz. of water dissolving 2 dr. of aniline. Ordinary white or yellow soap is shredded up and the mixture worked into it until the whole is a paste suitable for moulding. The above quantities are suitable for 2 lb. of soap.

Dyeing Lace Curtains.—For

a yellow or sage-green, proceed as follows: Dissolve a little picric acid in water to form a yellow liquid; this will serve for yellow. For a green tinge add a small quantity of deep laundry blue. Add these to the starch in which the curtains are dipped. For a red colour, make a solution of Congo red dissolved in 4 gal. of water. Warm this, dip the curtains, and work them about with the hands to make the colour penetrate; then wring, dip in cold water, wring again, dry and mangle.

Spirit Dyes.—The following dyes are soluble in alcohol (methylated spirits): Picric acid, brilliant yellow, phosphine, aurantia, auranum, magenta, cardinal, acid magenta, phloxine, cerise, safranine, erythrosin, rose-bengal, coccine, methyl orange, curcumin, metanil yellow, naphthol yellow, chrysoidin, chrysophenin, mandarin, Humboldt blue, induline, spirit blue, navy blue, peacock blue, benzyl blue, methylene blue, rosaniline blue, Hoffmann violet, methyl violet, regina purple, acid mauve, new violet, acid violet, methyl green, brilliant green, malachite green, Bismarck brown, brilliant black, and nigrosin.

Simple Dyes for home use.—The following are specially intended for those living in isolated districts, where special dyes and dyeing materials are practically unavailable.

First it may be stated that in almost every case a fixing material or fluid is required, this being usually termed a mordant. The common rule is to use alum for fixing ordinary reds, blues, yellows, and greens, ½ lb. of alum to 2 gal. of boiling water. For deeper colours, such as black, purple, violet, and the heavy browns, acetate of iron is used. For scarlets and brilliant reds of this shade "tin liquor," or muriate of tin, is required. To make this, obtain some tin filings (or pour some molten tin into cold water from about 6 ft. height, which will reduce it to small particles). When dried put the tin in a bottle, pour in 12 oz. muriatic acid (known also as spirits of salts) then add, a little at the time, 8 oz. of sulphuric acid. The latter must be added slowly or the heat will break the bottle. When ebullition has ceased stopper the bottle and let it stand a day. It will keep good for a year or more. This mordant can often be obtained ready prepared at a druggist's, with directions for use.

As previously stated in this chapter all goods to be dyed must be washed perfectly clean, all grease, or size, or "dress," being removed. Failing this the work will finish patchy or spotty.

After dyeing goods, they should be dried, or at least well aired, before washing out the superfluous dye. Silk and merino dresses should not be wrung. When hanging to dry, let all shawls and dress goods be fastened up by their edges so as to dry evenly.

Whenever using logwood chips as a dye, boil them for ½ hour; or to hasten matters, they may be tied up loosely in a bag, and be boiled with the goods (though it is not so good a plan); or the extract may be used, 2½ oz. of this being equal to 1 lb. of chips.

For Woollen Goods.—*Black.*—Prepare a mordant of copperas, ¼ lb. to 2 gal. of water, boiled together. (This is also known as green vitriol; blue vitriol may also be used.) While boiling, dip the goods for about 40 minutes, airing them between; or the goods may be boiled in the solution for 15 minutes, which is quicker, but not quite so good. Have ready a dye made by boiling 2 lb. of logwood chips for ½ hour. Immerse the goods in the boiling dye for 1 hour, then air and immerse again for ½ hour; or the goods may be boiled in the dye for 1 hour. Dry thoroughly and afterwards wash in suds to remove superfluous dye. Rinse, and then press or iron out, using a damp linen sheet between the iron and the dyed goods.

Scarlet.—For 2 lb. of goods. 1 oz. well pulverised cochineal, 1 oz. cream of tartar, 5 oz. tin liquor, water. Boil together, then put in the goods working them about for 10 minutes, afterwards boiling for 1 hour. Stir occasionally when boiling. Finally, wash in clear water and either finish as described with black, or dry in the shade.

Pink.—The same quantity of cochineal and cream of tartar, but no tin liquor. First boil 1 lb. of alum in water for the mordant, and dip the goods in this for 1 hour, then follow with the dye.

Snuff-Brown.—For 1 lb. of goods. 4 oz. of cam-wood; boil this for 20 minutes. Dip the goods for ¾ hour. Remove goods, and add to the liquor, ½ lb. fustic. Boil for ¼ hour, and dip the goods again for ¾ hour. Remove goods and add ¼ oz. blue vitriol, 1 oz. green vitriol (copperas). Boil up, and dip again for ½ hour. More green vitriol will darken the colour. It is permanent.

Madder Red.—For 1 lb. of goods. 5 oz. alum, 1 oz. cream of tartar, water. Boil together, then put in the goods and boil for ½ hour. Take them out to air for a little time, and boil for ½ hour longer. Now in another pan put sufficient bran to half fill it and then fill up with water. Make it slightly warm, and let it stand until the bran rises. Skim off the bran and put in ½ lb. madder. Put in the goods and boil up slowly. When the water boils, the dyeing is finished. Wash in suds.

Green.—For 1 lb. of goods. 1 lb. fustic, 3½ oz. alum, water. Steep until most of the strength is extracted; then soak the goods until a good yellow is obtained. Remove the fustic, and add extract of indigo (also known as chemic) a very little at the time until the desired green is obtained.

Indigo Extract.—This is used for a blue colouring and is made as follows: Take 1 oz. of finely ground indigo and stir it into ¼ lb. of oil of vitriol and stir for 30 minutes. Cover over, and let it remain for 2 or 3 days, giving it a stir occasionally. Then stir in a ¼ teaspoonful, or less, of carbonate of soda to neutralise the acid. Store in a glass bottle, and it will keep well. It can often be obtained ready prepared at druggist's.

Blue.—(1) For 1 lb. of goods, 2½ oz. alum, 1½ oz. cream of tartar; water. Boil together, then boil the goods in it for an hour. Prepare some warm water with indigo extract in it to the colour desired, and boil up. Add more indigo if desired.

(2) Boil together 2 gal. of water, 2 lb. logwood chips, ½ oz. Brazil-wood, and ½ lb. green vitriol (copperas). Strain clear of the chips, then boil the goods in the liquor.

FOR COTTON AND LINEN-WOVEN GOODS.—In all cases cotton or linen goods should be boiled in strong soapsuds or weak lye to make them clean, the suds or lye being then carefully rinsed out with clear water.

Black.—Some trouble is always necessary to get a permanent black on cotton goods. For 1 lb. of goods. Take ½ lb. sumach (wood and bark together), and boil ½ hour. Let the goods steep in the liquor 12 hours. Dip in lime-water for ½ hour. Add to the sumach liquor 1½ oz. of copperas, and dip for another hour. Dip in lime-water again for ¼ hour. Make a dye of ½ lb. logwood chips boiled for 1 hour, and dip the goods in this liquor for 3 hours. Add ½ oz. of bichromate of potash to the logwood dye, and finally dip 1 hour. Wash in clear water and dry in the shade.

Blue.—(1) Boil together 2 gal. of water, 2 oz. of sulphate of indigo, and ¼ lb. potash. Dip the goods and let them lie in this for a day and a night. Wring out, and dip in a fixing bath of ¼ lb. of alum dissolved in 2 gal. of boiling water. Let the goods be in this bath for 3 hours. The goods are best hung to dry in open light as the colour is improved by this.

(2) First steep the goods in an alum fixing solution, then dye in a liquor composed of ¼ lb. of chemical blue to 2 gal. of water. Let the goods be in the dye a day and a night.

(3) For cotton 5 lb., or linen 3 lb., bichromate of potash ¾ lb. dissolved in boiling water; put in the goods and dip 2 hours, then take out, rinse; make a dye with logwood 4 lb.; dip

in this 1 hour, air, and let stand in the dye 3 or 4 hours, or till the dye is almost cold, wash out and dry.

Green.—(1) Dip the cotton in the home-made blue dye-tub until blue enough to make the green as dark as required, take out, dry, and rinse the goods a little. Make a dye with fustic ¾ lb.; logwood 3 oz. to each lb. of goods, boiling these 1 hour. When cooled to bear the hand, put in the goods, move briskly a few minutes, and let lie in 1 hour; take out, and let thoroughly drain. Dissolve and add to the dye, for each lb. of cotton, blue vitriol ½ oz., and dip another hour; wring out, and let dry in the shade. By varying the quantity of logwood and fustic, any shade of green may be obtained.

(2) For cotton or linen. First boil the goods in a fixing solution of alum and water, then make a dye of 2 gal. of water, with 2 oz. of indigo, and 2 oz. of turmeric. Boil the goods in this until the desired tint is obtained.

Yellow.—First boil the goods in a fixing solution of alum and water, then boil in a dye made of annatto or turmeric boiled in water.

Sky-Blue.—For 1 lb. of goods. Blue vitriol 1½ oz., water. Dissolve by boiling. Dip the goods 3 hours, and then pass them through lime-water.

Brown.—A very good brown is obtained by dyeing for sky-blue as last explained, then passing the goods through a solution of prussiate of potash.

Buff.—Boil together 3 gal. of water, ¼ lb. annatto, and ½ lb. potash, stirring well. Put the goods in this and let boil for 10 minutes. Stir well all the time. Remove the goods and put them direct into cold clear water, and rinse. Hang out to dry without wringing.

SILK GOODS.—These must first be washed clean so as to remove all grease or "finish," as, failing this, the dye may not take evenly, and cause much disappointment.

Black.—Take 2 gal. of vinegar, and boil this with 2 lb. copperas, 2 lb. logwood chips, and 2 oz. of nut-galls (bruised). Let the mixture boil 30 minutes (until it is dark). Drain off the liquor, and boil the goods in this until they are the shade desired. Rinse in clear water, and dry.

Brown.—(1) (Cinnamon). Prepare a solution by boiling 2 oz. of blue vitriol in 1 gal. of water. Dip the goods for 15 minutes, then run them through lime-water. Dip the goods in a solution of 1 oz. of prussiate of potash to 1 gal. of water. The first dipping will make the goods bright blue, while the latter will change it to brown.

(2) If the goods are boiled in a decoction of the peels of green walnuts, a good brown will be obtained.

Reddish-Brown.—Boil the goods in a liquor made by boiling oak-bark in water.

Sky-Blue.—Follow the first part of the process for cinnamon brown, just explained.

Blue.—Prepare a fixing bath of 1 lb. of copperas boiled in 1 gal. of water, and dip the goods in this. Make a dye bath of 1 gal. of water, 3 oz. alum, and sufficient indigo extract or chemic (already described). The indigo extract must be added in very small quantities at the time until the right shade is obtained. The more of this that is used the darker the goods will be.

Crimson.—For 1 lb. of goods. Dip the goods in an alum fixing bath, then in a dye bath as follows: 3 oz. cochineal, 2 oz. bruised nut-galls, ¼ oz. cream of tartar, 1½ gal. water. Boil together 10 minutes, then allow to cool. When a little cool put in the goods, and boil up and keep it at this for 1 hour.

Yellow.—(1) For 1 lb. of goods. Make an alum fixing solution, and add ¾ oz. of sugar of lead to it. Let the goods be in this 12 hours, then take out, and drain. Make a dye with 1 lb. of fustic, and dip the goods until the required colour is obtained.

(2) For 1 lb. of goods. Take ½ lb. of yellow oak-bark, and boil for ½ hour. Strain off the liquor, and add 6 oz. of alum. Dip in this.

Green.—(1) Proceed as for (2) yellow, and before dipping in the bark liquor, pass the goods through the home blue dye-tub. Dry, and then lightly wash, and dip in the bark liquor. It will take better if the liquor is warm, not quite cold.

(2) Prepare the bark liquor, and add extract of indigo, a little at the time, working the goods and lifting them out to air as each addition of indigo is made.

* * *

EARTH CLOSETS.

WE are indebted to J. Donkin, Esq., F.R.I.B.A., for the following description of his admirable system of dry sanitation.

In these days of "advanced" sanitary science it is the fashion to look at the dry system as belonging to a retrograde movement, notwithstanding the fact that water-carriage, which is the essential feature of this so-called advance, is universally admitted to be wrong, and deprecated by the first scientists of the day. The anomaly, however, is not so difficult to explain, nor even to justify, in view of the facilities that water affords for rapid disposal under the crowded conditions of town or city life; nevertheless it should be borne in mind that this system is in the nature of an expedient, to be avoided wherever possible, and that its success necessarily entails an enormous waste at a ruinous cost, while the dangers attending the reckless and wholesale pollution of water constitute one of the most pressing evils with which it is possible to threaten mankind. Indeed, we might fairly say that the more perfectly the water system is applied, the greater the danger which must eventually arise from it.

It is in view of these evils that the advantages of the dry system become more apparent, because this indictment is true of the water-carriage system in its modern and most approved form, whereas the disadvantages attending the dry system adhere chiefly to its rude and most primitive forms; and it follows naturally that the more it is improved as time advances, the less would be the inconvenience entailed. In either case, however, the principle does not admit of any compromise; each system must be drastic and thorough in its own way, or results follow which are experienced in many of the so-called water-closets abroad, and earth-closets at home, where the receiver in either case holds a compound which is neither fluid enough to travel nor dry enough to crumble, and the process of disposal is rendered as difficult as it is offensive to accomplish. In fact, it cannot be too plainly stated that the smell which generally arises from the ordinary form of earth-closet is practically in proportion to the amount of liquid which is allowed to collect in the receptacle provided; thus it will be found to subside when additional earth (or other deodorant) is added, and practically to disappear entirely as a dry condition is reached.

Hitherto the chief objections to the use of the dry earth system for closets arise either from a faulty application of the principle, or in not carrying it far enough to ensure its complete operation. Not very long ago the same thing might have been said in respect to the old, and now obsolete, methods connected with water-carriage, and both cases tend to show that whichever medium is adopted, the system must be carried through scientifically and completely in order to obtain satisfactory results. Thus, to speak more definitely, earth-closets which allow the excreta to become mixed with solids and liquids collected in one receptacle, certainly compromise, if they do not actually destroy, the main feature of the dry system, because the liquids being always in excess of the solids, render the process of absorption practically impossible, and put cleanliness out of the question. Primarily, it cannot be questioned that nature clearly teaches separation, the urine being separately secreted as well as voided, and the main object of a closet of this kind should be to provide the means for assisting and completing this principle in its entirety, and where this is done it will be found that most of the objections to which the dry system has been open in the past will disappear.

Clearly, therefore, it is essential that an earth-closet should be constructed in such a way as to keep the dry principle, as far as possible, intact, not merely in the perfunctory use of earth, or any other dry agent adopted, but by at once taking advantage of the natural impulses of the body, and perfecting the separation which nature commences. This, however, can only be attained by providing a dual container, or separate receptacles, so that any mixing of putrescible matter with water or urine is avoided, and each is rendered harmless by the dry and separate treatment which the problem requires.

In order to render the details of this principle more easy to follow than would be possible by closer verbal description, several illustrations are given which fully indicate the various parts of the scheme, and thus show the practical means which the author has adopted with increasing success to obtain the objects in view, viz. Separation; Evaporation of the Urine; Dry and portable products; No offensive smells; and Full manurial value.

In the most modern arrangements, a vessel is placed in front for the exclusive reception of the fluid matter, while a separate container is provided behind to receive the solid excreta and the earth, the latter being supplied from a hopper at the back of the seat, and regulated by a shute valve of simple construction, which, by a single action, both delivers and distributes the earth simultaneously.

When a closet is arranged in this way, the question of separation offers no difficulty whatever in the case of either sex. It is absolutely automatic and certain in action, and by no possibility, with fair usage, can the liquids enter the bucket, or the solids touch the pedestal. Hence, the soil receptacle is always in a dry condition, in which the natural process of humification is most active, and the operation of removal or distribution most easily performed.

It will be seen that this method presents a wide contrast to the earlier system now in use, in which both forms of excreta are collected in the same bucket, generally resulting in an offensive and dangerous slop emitting even worse gases than the sewer, and compelling the necessity for air-tight covers, with arrangements for special cleansing and disinfection before re-use is possible. By the plan of separation before referred to, the contents leave the bucket practically clean, and without the least smell or offence in any way. The treatment of the urine is then on much the same principle as the soil. In the case of a simple garden-closet it may be conducted to the earth direct, if the other conditions are suitable, or conveyed by open channels charged with sawdust or other deodorant, by which it will be readily absorbed or distributed.

It may also be treated by evaporation as in Figs. 1 and 2. In this case the floor of the closet may be raised a step, and the urine allowed to fall into a porous trough in a ventilated space underneath, which is supplied with some such material as earth, peat, sawdust, fine coke, or carbon. Naturally, the larger the surface exposed to the air, the sooner evaporation will ensue. Peat or sawdust has been found to absorb about eight times its own weight in urine, while the capacity of the other agents will vary from one to four times their own weight, and when the conditions are arranged as described, the evaporation will go on automatically and for an indefinite length of time. The process may be explained by the fact that the salts and solids held in suspension, which emit such disagreeable odours when evaporating under ordinary circumstances, undergo nitrifaction when brought into contact with earth or any of the substances named, with the result that the solids are left behind in the earth, and the water alone is given off in the form of vapour, without any offensive odours whatever. No chemical antiseptic or deodorant is necessary to obtain this result, the only essentials being that the agent or medium used should be of a loose and absorbent nature, and the more air that is admitted the better the result. The rate at which evaporation actually takes place will naturally depend upon the quantity of urine admitted in relation to the evaporating surface exposed, and the climatic conditions prevailing; but the principle admits of application on any convenient scale. It would, however, be a comparatively simple matter to arrange the various parts so that the provision for evaporation shall at least balance or preferably exceed the amount of fluid likely to be admitted. But even if the in-take should by chance exceed the absorbing capacity of the bed provided, no further trouble need be anticipated than that the surplus or filtrate would

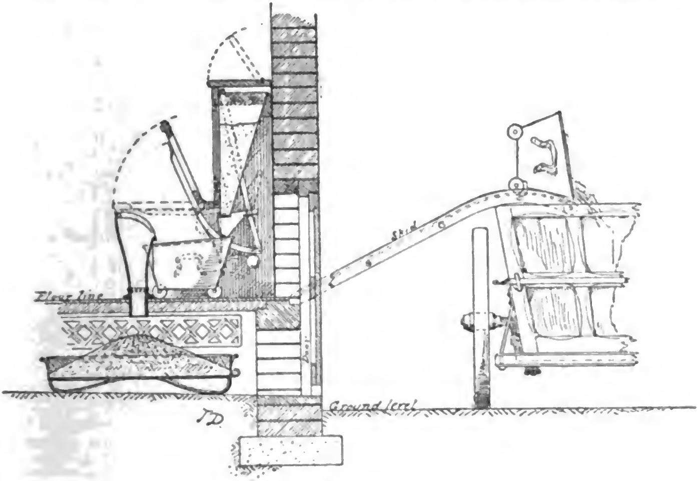

FIG 1.

run into the surrounding earth as a comparatively pure and colourless water. At intervals of 1 to 3 months, or even more, it might be felt desirable to change or use the earth in the contact bed or evaporator; but as it assumes a form scarcely to be distinguished from the ordinary garden mould, the removal presents none of the usual difficulties and risks attending the mixed systems, and the product is always of the highest commercial value as a fertiliser.

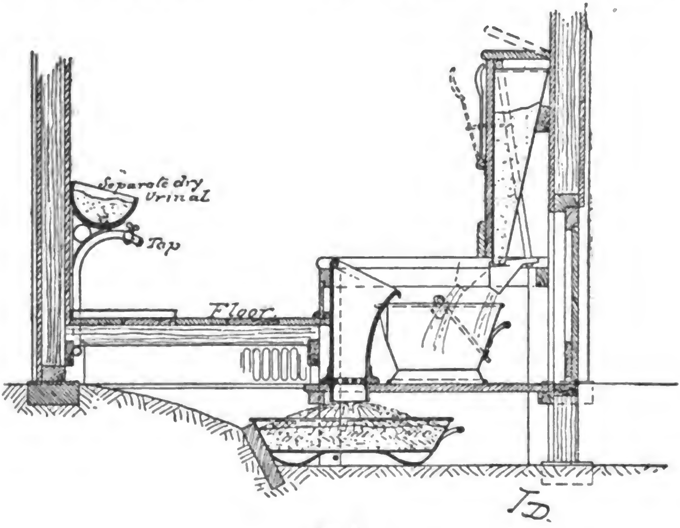

FIG. 2.

In Fig. 2 will be seen an illustration of a dry closet on the separating principle, but at the same time adapted to native Indian customs, with a view to meeting some of the difficulties experienced in that country. The principle being much, however, the same as in those already described, it is scarcely necessary to enlarge on the details, which are sufficiently clear in the drawing. It is only, perhaps, needful to say that the top, which in the ordinary way forms a seat, is here adapted for standing, while the space under the floor becomes a ventilating shaft right through for assisting evaporation in the trough, or earth below, receiving the fluids. Then on the handle being pulled as indicated, the earth is promptly discharged, and the shute returns to its normal position by a weight or spring.

Disposal of Earth.—By one method the bucket is removed by a trolley somewhat similar to a barrow with handles, when it can be wheeled on to the ground direct or removed in any other convenient way.

Another method is shown in Fig. 1 by which the space between the bucket and the cart is bridged over by a skid with grooved sides, and the bucket, being mounted on wheels, can be easily run up or down the skid, the contents tipped into the cart as indicated, and the bucket replaced. The soil from these closets may be dug in at once, or stacked for a few weeks, and allowed to humify, or even re-used 3 or 4 times if sufficient interval is allowed between for the natural amalgamation to take place—and this without any appreciable deterioration of its absorbent power or disagreeable smell arising from it.

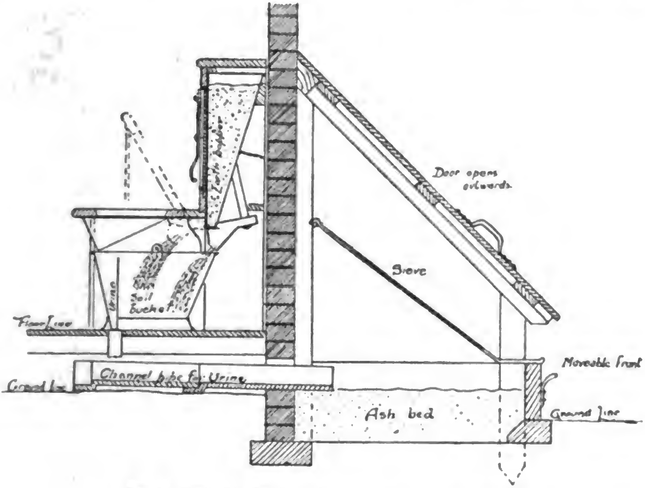

FIG. 3.—GENERAL SECTION THROUGH CLOSET AND SIFTER.

To ensure the proper action of all earth or dry closets, it is important that the earth, ash, or other agent should be properly sifted and fairly dry. The former process can be readily accomplished by an ordinary sieve of not less than four meshes to the inch; and no artificial heat is required for the latter.

An alternative arrangement is shown in Fig. 3, in which the soil bucket is divided by a partition which obviates the use of a special pedestal. The ash bed is covered by a sloping door with opening at bottom which admits of thorough ventilation.

For further information on this subject, readers are referred to Mr. Donkin's pamphlet on 'Conservancy or Dry Sanitation' (E. & F. N. Spon, Ltd.).

* * *

EBONITE AND VULCANITE.

(*See also* INDIA-RUBBER.)

(*a*) These two materials are practically the same substance the main difference being in the colouring materials used. They consist of india-rubber and sulphur, practically the same as vulcanised india-rubber, but a greater heat, and time, are employed to vulcanise the compound. To prepare it as sold in the form of combs, toilet and fancy articles, the rubber is worked in a masticating machine with the proper quantity of sulphur, and when thoroughly mixed a sufficient quantity is put into a mould of the right shape made of plaster of Paris, or other material which will not combine with sulphur, and exposed in a steam boiler to a heat of 315° F., and a pressure of about 12 lb. to the inch for 2 hours. It is then removed from the mould, and finished, and polished exactly in the same manner as ivory. The application of heat as above without a steam pressure is sufficient to vulcanise or harden the compound, but the result is not always so satisfactory, as the material is liable to be porous, if not compressed whilst hardening. Gutta percha may be treated in exactly the same manner as rubber, and cannot be distinguished from it, but is rather more troublesome to work. The vulcanite may be turned or carved in the same way as ivory, with the advantage that it may be moulded to the required form without the great waste which attends ivory carving. It is also much less liable to fracture. The smaller the proportions of sulphur in the rubber, and the lower the temperature used, the softer and more elastic will be the rubber. About 10 or 15 per cent. of sulphur, and a temperature of 270°–275° F. for 4 hours, will make an elastic rubber; 30 per cent. of sulphur and a temperature of 315° F. for 2 hours will make a hard vulcanite like ivory.

(*b*) To make vulcanite about equal parts of rubber and sulphur are used to which is added about 7 to 10 per cent. of lamp-black. These are all worked together in the masticating machine. A very useful vulcaniser for small goods is that made for dental work. It usually takes the shape of a cylindrical iron vessel with bolted-on lid, and fitted with a pressure gauge, thermometer, and safety valve. Perforated divisions are put inside for the articles to rest on. With the simple vulcanisers the required heat is obtained by putting a little water in the bottom of the vessel, then lighting a burner underneath to create steam which soon reaches a high pressure and temperature. The safety-valve is set to blow off at the proper pressure. Larger vulcanisers are steam jacketed, which is no advantage except where high-pressure steam is available. The heat for vulcanising should be slowly raised, the whole process being extended to about 4 hours, the final and highest temperature being 150° C. (302° F.). In large works the vulcanising chamber is a horizontal cylindrical oven with door in one end, free high-pressure steam being used, supplied to the interior (without a jacket). It may be explained that the pressure and temperature of steam go together, and for 302° F., the steam pressure would be 55 lb. on the gauge.

(*c*) Vulcanite can be worked with ordinary wood cutting, sawing or turning tools, as it works much like ivory. It is desirable to keep vulcanite cool when working it, as it heats rapidly and softens with heat. At the boiling point of water vulcanite can be bent and, when cold, will retain its new shape. At a little higher temperature vulcanite is soft enough to be impressed with a pattern, or to be moulded.

(*d*) The following are useful hints which appeared in the 'American Machinist,' relating to the working of ebonite.

The best qualities show on fracture a brightness something of the nature of jet, and the poorer sorts a corresponding dulness. Although an apparently easy material to machine, its wearing effect on cutting tools is comparatively great. In sawing, turning, planing, or milling, the best speed is that at which brass is machined, and milling should always be accompanied by the free use of soap and water, having regard to the fact that a milling cutter is an expensive tool; but for turning or sawing, lubricants are in the way, on account of the spattering round of ebonite cuttings and soapy water.

When turning ebonite it is always preferable to leave the tools dead hard with a lot of "rake" on, and to take as deep a cut as possible, with a slow feed. Herein will be found the advantage of the tool-holder system for turning tools, in which the cutter can be taken out and replaced by a fresh one, saving thereby a good many journeys to the grindstone; for the moment a cutter becomes dull, which is frequent,: instead of cutting it "burns" the surface of the material, and, of course, militates against the production of good work. When tapping ebonite the writer has always found soft soap to be the best lubricant.

Oil should never be used as it works into the material and in time rots the thread. Taps made of rod brass will be found useful, for if a dozen or two holes are executed with an ordinary tap, it will be comparatively useless on metal. Brass taps are easily made, and last almost as well as steel. Reamers of brass can be used in the same manner; an ordinary nose type with four saw-slits made in the end, and a tapped hole admitting a taper screw for expanding the tool as it becomes worn, is as handy and as cheap a method of reaming holes in ebonite as the writer knows of. When worn, it can be headed up easily and made ready for use again. In shops where ebonite is used it is nearly always found necessary to do a lot of sawing, and it will be found best not to use expensive tools. The writer has seen good saws—properly ground for clearance—rendered useless after a day's work on this material, and has found home-made sheet-steel saws as good as the more expensive ones for cutting, besides being more readily sharpened, the necessary clearance being given to them by setting the teeth over sideways. Although of a brittle nature, the thinnest sheets can be worked in the press up to a thickness of about ·02 in., keeping the tools and materials warm by means of a gas-jet, and, although the stampings come out rather rough on the edges, they will be found suitable for jobs where a smooth edge is not desired.

In polishing ebonite, after taking all tools marks out with emery paper (commencing with F.F. and finishing with No. 1. blue-black French paper) a lap of hard felt charged with bath brick and oil is used, after which another lap charged with rottenstone and oil will be found to give good results: at the same time taking care not to exercise too much pressure, for an excess of friction "burns" the surface of the ebonite, rendering it incapable of taking a high polish. If a dead finish is desired, all that is necessary, after using the emery cloth, is for the surface to be rubbed over with a cloth damped in paraffin.

* * *

ELECTRIC BATTERIES.

THEIR CONSTRUCTION AND MANAGEMENT.

Bichromate. — (*a*) Bichromate batteries of bottle shape as in Fig. 4, with 2 carbon plates, a sliding rod and movable zinc plate, are very extensively used by experimenters and lecturers, because they are always ready for being put to work with one motion of the hand, not necessitating any other preparation; and as soon as the desired result is obtained, the battery can be put out of action with the same facility. *a* is the bottle; *b*, a brass cap for the top; *c*, a disc of ebonite, to which the carbon plates are fastened; *d*, a binding screw, connected with the 2 fixed and parallel carbon plates, between which is suspended a zinc plate of about half the length. This plate of zinc is fixed on a brass rod, whose extremity is shown at *f*, made to slide up and down in a brass tube, which is either close-fitting and split, or loosely-fitting and provided with a set-screw. In either case, it must be connected, by means of a copper band, with the terminal *e*. The excitant is a saturated solution of potash bichromate, to which is added $\frac{1}{10}$ volume of sulphuric acid; another $\frac{1}{10}$ should be added after the battery has worked for some time, when it begins to become weaker in action. For all purposes where a strong current is required at intervals, such as the working of induction coils, medical coils, small electro-magnetic machines, and laboratory experiments, this battery is by many preferred to all others. The prices of such batteries range from 6*s.* 6*d.* to 24*s.*, according to the sizes and number of the plates, 3 carbons and 2 zincs being employed in the largest apparatus of the kind. Amateurs can hardly make this kind of battery so cheaply as it can be bought, because the bottles are high in price unless ordered in large numbers at a time.

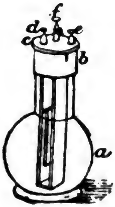

FIG. 4.

(*b*) For this reason, Wiesendanger devised a form of bichromate battery having all the advantages of the one described above, and which can be made by amateurs at a fraction of the prices quoted. To make such a battery, take a marmalade jar *g*, measuring inside about 5 in. by 2½ in. diameter at the top. Get 2 plates of carbon, each 5 in. by 2½ in., and a zinc plate (with terminals) of the same dimensions. Cut 2 pieces of thin mahogany board, 3 in. by ½ in. by ⅛ in., and a clamp *c*, such as shown in Fig. 5. The clamp *c* should have a ring at *a*, at the top, so that it can be suspended from the hook *b*, when the battery is not in actual use. The 2 pieces of wood *d* are put right and left to the top of the zinc plate *f*, as shown, the 2 carbons *e* to the right and left of the pieces of wood, and the whole arrangement is clamped by means of the top-clamp *c*. The frame can be made with a piece of bent brass strip *h*, 9 in. × ½ in. × $\frac{1}{16}$ in., to which the upright brass rod *i* is soldered; or it may be made of stout brass wire,

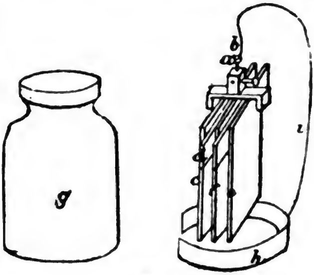

FIG. 5.

No. 7, altogether. In either case, there will be so much elasticity in the ring *h*, that it can easily be put on, and will hold firmly on the top of the jar. This frame can be bought ready made for 10*d*. When the battery is to be used, the plates are inside the jar and in the liquid, supported by the projecting ends of the wooden pieces *d*; when out of use, the plates are lifted and suspended from the hook *b*, by means of the ring *a*, at the top of the terminal clamp.

(*c*) Trouvé considerably improved the bichromate battery by supersaturating the exciting fluid. He takes 21 dr. of potash bichromate powder to 1 pint water, and adds, after shaking, drop by drop, 63 dr. sulphuric acid. The liquid warms, and the salt dissolves. No cyrstals form on cooling, nor are chrome-alum crystals deposited in the cell. The electromotive force of the 12 element cell is 2 volts with fresh solution, and the intensity of the current at the beginning of a short circuit is 118 ampères. The resistance is 0·07 ohm; 4 batteries working a Gramme machine have produced 14 kilogrammeters of work during 3 hours without weakening in power.

(*d*) In working bichromate batteries, never place or leave the zincs in the excitant when the current is not needed; remove them the instant the battery is out of use; and when in use, do not let them rest in the fluid for 5 minutes without disturbing either the plates or the fluid. The great defect of these batteries is the want of circulation in the fluid, and consequent decrease of the current. By applying heat sufficient to cause agitation, the current will retain its vigour almost till the solution is exhausted. Spent fluid may be evaporated down to recover the chrome-alum usually formed. A very convenient form of compound bichromate battery, is to have the plates attached at top to a support which can be raised by allowing it to depend by strings from a spindle; on revolving the latter, the strings coil on the spindle and raise all the plates at once. As to the number of bichromate cells required to give an electric light: 6 1-qt. cells will give a small light; 12 yield more than double; 24 afford a true voltaic arc and a brilliant light; 50 produce a light of 1500 candle power. Up to 50 1-qt. cells it is best to connect in series; any greater number should form a separate parallel circuit; and, finally, the negative wire from each series is led to one screw of the lamp and the positive to the other. By this arrangement, the electromotive force of the battery is not increased (that of 50 cells being usually enough), while the resistance of the elements that are doubled is halved. The guiding rule for grouping a given number of elements is to effect it so that the internal resistance shall equal the external. Not more than ½ hour's continuous light can be got from any bichromate battery. (Urquhart and Webb.)

Bunsen's. — (*a*) Bunsen's zinc-carbon battery is a modification of Grove's, the only difference from the latter being the substitution of carbon for platinum foil. The carbon rod or plate becomes brittle in time through the action of the battery, and should therefore not be too thin; this necessitates a much larger porous cell than in Grove's element, and makes the battery more bulky. It is, however, to be preferred to Grove's for (1) it is much less expensive, and (2) owners of Grove's battery experience that the valuable platinum plates offer a bad temptation to workmen, and at times disappear in a mysterious way.

In Fig. 6, A represents a single element of Bunsen's battery. *a* is the outer cell made of glass, earthenware, or vulcanite, the zinc-plate bent round, with a binding screw, *b*, at the top. *c*, a round porous cell, with a wooden lid at the top, through which a carbon stick or rod passes; another binding screw *d* is attached to the top of the carbon-rod. The wooden lid at the top is not absolutely necessary; instead of it, a clamp binding screw may be fixed at the top of the carbon (see B). Carbon is a very porous substance; if the top is not protected, the acid will rise in it by capillary attraction, and soon destroy metallic fixtures by oxidation. For this reason, the top of each carbon plate or rod should, before being first used, be soaked in hot melted paraffin wax.

If artificial carbon is used, it is put in the outer cell and shaped like C, in **Fig. 6.** The carbon rod described need not be carefully squared up—it may be of very irregular shape; pieces of the hard coke obtained as scurf in gas resorts are sometimes employed, without being finished up. If a battery is fitted up with such pieces of carbon, the latter should be as nearly as possible of equal size.

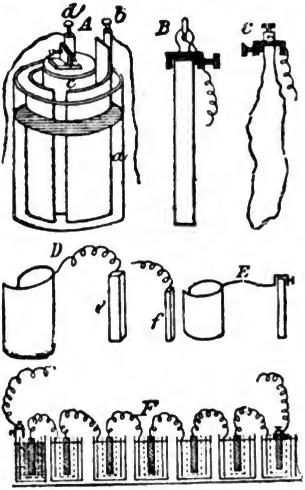

FIG. 6.

Strongest nitric acid is put into the carbon cell, and acidulated water, 1 to 10, or 1 to 12, into the zinc cell. The action is similar to that in Grove's cell.

(*b*) An improvement upon the common practice of simply clamping the carbon by a binding clamp of brass for the connection, is to give the block a heading of lead. Dry the head, cut a notch or two around it ¼ in. from the end; melt the lead, and pour it into some square mould; before it sets, dip in the carbon end; allow to solidify before removal. While still hot, the binding screw may be soldered on, and, before it cools, the whole should receive a coating of shellac except for the points of contact which must be scraped bright or filed.

The force of the Bunsen increases after setting up for about an hour, and the full effect is not attained until the acid soaks through the porous cell. Carbons are not affected, and last any length of time. The zinc is slowly consumed through the mercury coating.

(*c*) Each element is composed of a glass vessel which is half filled with nitric acid at 36°–40° B., and which receives a hollow cylinder of pulverised coke, moulded and cemented at a high temperature, by sugar, gum, or tar. At the upper part of this cylinder, where it does not dip into the acid, a copper collar is fixed, which may be tightened at will by means of a screw. A copper band or ribbon is fixed to the collar, and may be connected with the zinc of another element. A porous porcelain cell is placed inside the coke cylinder, and contains a diluted solution of sulphuric acid, 1 part acid and 9 water, into which is put a bar or cylinder of zinc strongly amalgamated, or covered with mercury. When a battery of several elements is to be formed, the coke of the first element is connected with the zinc of the second, and so on, and the apparatus is completed, at one end, by coke communicating with the anode, and at the other, by a zinc connected with the cathode, or object to be electroplated. In this apparatus the surface of the carbon is much greater than that of the zinc; this is a wrong disposition, since, generally, the intensity of the current is in direct ratio with the surface of the zinc corroded, provided that this surface be opposite and parallel to that of the carbon.

(*d*) *Bunsen's Modified by Archereau.*—This battery is preferred by gold and silver platers. Each element is composed of an exterior vessel or pot, most generally of stoneware; a cylinder of zinc, covered with mercury, provided with a binding screw, or with a copper band, whether for a single element, or for the end of a combination of elements in a battery, or to connect the zinc with the carbon of another element. A porous cell of earthenware pipe or porcelain. A cylinder of graphite, made from the residue found in old gas retorts. The graphite is bound by a copper band fixed to it by means of a wire of the same metal, all the binding being afterwards covered with a thick varnish to protect it from the acid fumes of the battery; notwithstanding the varnish, the acid may rise by capillary attraction, and corrode the copper band between the carbon and the wire, therefore binding screws of various shapes and sizes should be used to connect the carbon on zinc by means of ribbon or wires.

(*e*) *Management of Bunsen Batteries for Electro-plating.* — Taking as a standard the usual element 10 in. high and 6 in. in diameter, half fill the stoneware pot with water; add 7 oz. sulphuric acid at 66° B., and 1 oz. of amalgamating salt; or the zinc may be amalgamated with metallic mercury (after it has been cleansed in diluted sulphuric acid) by being dipped into mercury, or rubbed over with this metal by means of a scratch-brush of brass wire. Put the zinc cylinder into the stoneware pot; then introduce the cylinder of carbon into the porous cell; fill the empty space between the carbon and the sides of the cell with nitric acid at 36°–40° B.; place the porous cell thus filled into the centre of the zinc cylinder. The surfaces of the two liquids should be level.

When several elements are to be connected, they are placed near each other, without touching, and the first carbon or graphite is left free for the attachment of the anode. The ribbon or band of the first zinc is pinched between the jaws of the brass binding screw, and the carbon of the second element, and so forth, until the last zinc is ready to be connected with the object to be electro-plated.

Bringing into Action. — Batteries will furnish electricity when the circuit is closed, that is to say, when the conducting wires starting, one from the carbon, and the other from the zinc, are put into communication, whether by direct contact or through the medium of a conducting liquid. It sometimes happens that batteries, which appear to be in good order, do not work. This is generally due to some foreign substance preventing the conductibility at the points of contact, or to the copper band of one zinc resting upon another zinc. Before using a battery, try if the current escapes well from both extremities. For this purpose present the point of the negative wire to the carbon of the other end, and a spark should immediately ensue. The same experiment being made with the positive wire, against the last zinc, another spark should be produced; or it is still more easy to have the two ends of the wires made to rest at a short distance from each other upon a piece of carbon, or upon a file, and then rubbing with one wire while the other remains in contact. Numerous sparks will immediately appear. When one element of a battery is wrongly put up, discover the defect by successively presenting the end of one of the wires to the carbon of each element, and that which does not produce any spark belongs to the defective element. Too much porosity in the cells is another cause of stoppage in the current, because the solution of zinc which penetrates deposits upon the carbon a whitish coat preventing further action. Change the cell and scrape off the coat entirely from the carbon. This generally takes place when the battery has been working several days without the addition of fresh liquor, or when there is too much acid. The battery will also cease working from too great an accumulation of zinc sulphate, which, not having sufficient water to remain in solution, crystallises upon the zinc, and prevents any further action. Remove the acid solution, substitute a fresh one, and clean the zinc. Laminated zinc is preferable to that cast in a mould, because the latter is not so homogeneous, and is more rapidly corroded, and even perforated.

Keeping in Order.—Every 24 hours, or oftener, the losses of batteries must be made good by adding, without taking the elements apart, about two teaspoonfuls of amalgamating salt, and as much of sulphuric acid, to the liquor of the zinc plates, and stirring with a glass rod. Nitric acid, to replace that evaporated, is put into the porous cell. This manner of operating may be sufficient for 5 or 6 days; but after this lapse of time, all the old liquors must be removed, and fresh ones added. Although amalgamated zinc is scarcely corroded, even in a very acid solution, when the two poles are not in connection by direct contact, or through a conducting liquid, it is preferable to take the batteries apart every evening, in the following manner: All the binding screws are let loose, and cleaned; the cylinders of carbon are removed, and, without washing, deposited in a vessel especially for their use; the porous cells are removed, and their acid is poured into a special vessel. The cells are not washed; the zincs are removed from the acid liquor, and placed in an inclined position upon the edges of the stoneware pots; the batteries are made ready to work by a converse manipulation.

Batteries must be kept in a place where the temperature does not greatly vary. A frost arrests their action, and great heat increases it too much. A good place for them is a box, and they are put at such a height that they may easily be manipulated. This box should have means of ventilation, in such a way that the air coming in at the lower part will escape at the top through a flue, and carry away with it the acid fumes constantly disengaged. It is best to keep the batteries in a room different from that where the baths and the metals are to be operated upon, as these are easily injured by acid vapours. The galvanic current may be conducted into the workroom by wires passing through holes in the wall.

Porous Cells.—The porous cells are absolutely necessary in batteries working with two exciting solutions. But the trouble arising from the clogging of the pores of the cell, and from the difficulty of preventing the diffusion between the two liquids of the porous cell and of the jar, the specific gravity of which is constantly varying, makes it desirable that the cell should be dispensed with in batteries worked with but one exciting fluid.

Callaud.—The Callaud battery is a modification of that of Daniell, doing away with the porous cell. A jar is filled with water acidulated with sulphuric acid, only for starting the solution of the zinc, as the sulphuric acid will be furnished afterwards by the copper sulphate. The zinc and copper plates are both placed horizontally in the jar, the zinc in the upper part, and the copper lying on the bottom. To start this battery, throw into the jar a few crystals of copper sulphate. These go to the bottom, dissolve, and form a saturated solution around the negative plate of copper. The electrode or conducting wire from the copper plate may be made to pass through a glass tube reaching down to the bottom of the jar, and large enough to contain a supply of crystals of copper sulphate necessary to keep a saturated solution in the lower part of the cell. This avoids disturbing the upper part of the liquid in which the zinc dips, and its mixture with the solution of copper sulphate. · The deposits from the zinc and other impurities are prevented from falling upon the copper-plate, and thus interfering with the current, by covering the copper plate with a layer of clean quartz sand, which serves also as an obstacle to the effusion upward of the copper sulphate, because the interstices between the grains act as a series of narrow tubes, but the force of the current diminishes by reason of the increased resistance.

Daniell's.—(*a*) This battery develops a constant and lasting current, but is wanting in intensity. It is especially adapted to slow deposits, which must be thick and of uniform texture. A great advantage of this battery is that it will work without acids, and therefore without the production of gases or smell, and can be used in a private apartment without inconvenience. The vase for the battery is a flat vessel of pure copper, which is half-filled with a saturated solution of copper sulphate, into which is placed a bag of canvas or a cell of porous porcelain or earthenware, which causes the solution of copper sulphate to rise to about 1 in. from the top of the copper vessel. The bag or cell is filled with a saturated solution of common salt, in which a well-cleansed zinc-plate is placed. It is necessary that the levels of the two solutions should be nearly the same. If there is any difference, the solution of sodium chloride should be slightly above the other, because if the solution of copper sulphate passes into the porous cell, the zinc is immediately corroded and blackened, and the battery may cease to work. When one of Daniell's elements only is used which seldom happens, on account of the feeble intensity of the current, the conducting wire which supports the article to be galvanised is connected with the zinc-plate by a binding screw of brass, and the other wire supporting the anode is connected with the copper of the exterior vase. The solution of copper sulphate must be kept constantly saturated with crystals of this salt, enclosed in a bag of linen or hair-cloth. A similar process may be employed to keep the solution of common salt in a state of saturation. A battery thus arranged may be kept in operation for 3–4 weeks. When this battery is working, the copper of the decomposed sulphate is deposited on the copper of the vessel, which thus increases in weight and in value. The zinc is slowly dissolved in the solution of common salt, and forms a double chloride of sodium and zinc. When a number of the elements of a Daniell's battery are to be joined together, the zinc of the first element is connected with the copper of the second by means of a well-cleansed metallic ribbon, then the zinc of the second with the copper of the third, and so on, until the whole apparatus presents at one end a copper vase, and at the other a zinc plate, unconnected. A metallic wire connects the anode with the copper end, and a similar wire is bound to the zinc end, and supports the object to be plated.

(*b*) Another battery used by the electro-gilders of watch parts and by telegraphers, is composed of a cylindrical vase of stoneware, glass, or porcelain ; a cylinder of zinc to which is soldered a ribbon of pure copper ; a porous clay cell, and a glass balloon with a short neck, and filled with crystals of copper sulphate. It is closed with a cork perforated with two holes, or having two notches cut along its sides. The rolled zinc plate is put into the stoneware pot, and the porous cell inside the zinc. The copper ribbon of the zinc of the first element dips on to the bottom of the cell of the next element, in such a manner that, when several elements are connected together, there is at one end the ribbon of a zinc plate, and at the other end a copper ribbon put into the cell. Then the porous cell and the stoneware pot are filled to the same level with water. The balloon containing the crystallised copper sulphate receives as much water as it can hold, and the notched cork being put in place, the balloon is quickly inverted with its neck in the water of the porous cell. The battery is ready to work 24 hours after. The ribbon of the zinc end is connected with the objects to be plated, and that of the other cell end, with the soluble anode. The copper sulphate contained in the balloon is dissolved in the water around it, and as this solution is denser than water it falls into the porous cells through one of the notches of the cork, while an equal quantity of purer and lighter water ascends through the other notch, and so on, producing a circuit of denser liquor falling by one notch, and of lighter liquor rising by the other. The solution of copper sulphate is decomposed in the porous cell; the sulphuric acid passes through the cell by outward pressure, and acts upon the zinc, and at the same time the copper becomes deposited upon the copper ribbon connected with the zinc of the former element. In order that this battery may work regularly for 6–7 months, it is sufficient to replace the evaporated water. The balloon ought to contain at least 2 lb. of copper sulphate, and the zinc to be about 7 in. high, and 4–4½ in. diameter. The zinc may be amalgamated, in which case the action is a little slow at the start, but more regular afterwards. The copper ribbon receives all the metal of the decomposed sulphate, and it sometimes happens that part of the copper becomes deposited upon the porous cell, which must then be cleaned in aquafortis. When all the copper sulphate is used up, the balloons are filled with a fresh quantity of crystals and new copper ribbons are inserted to take the place of those rendered too voluminous. If it be desired to start the battery with a balloon immediately, add a small quantity of sulphuric acid, or of common salt, to the water in which the zinc is placed.

(*c*) The Daniell battery consists of a copper cylinder containing another of porous earthenware, in which is placed a zinc rod; this latter forms the positive and the copper the negative element. The battery requires 2 excitants—a saturated solution of copper sulphate in the copper cylinder, and dilute sulphuric acid (1 volume oil of vitriol to 7 of water) in the porous cell. The walls of the latter keep the solutions separate, while allowing the electric current to pass through. The cathode and anode are formed by attaching binding screws to the zinc rod and copper cylinder. The battery requires no frame, is effective in use, constant, and gives a current of fair intensity. (Dyer.)

(*d*) To construct a home-made Daniell cell, select a small round earthenware jar, such as is used for keeping preserves, and having lined the bottom with guttapercha, or some suitable cement, to the depth of ½ in., fix upright in this a rod of zinc, of equal height with the jar, to which a length of copper wire has been attached by passing it through a hole drilled in the upper part of the zinc rod, or by soldering. Make a cylinder of pipeclay, or other porous clay, larger than the zinc rod, and having dried it, make it hot in the fire by degrees, till it attains a red heat. Let this cylinder cool gently, and when cold, place it in the jar round the central rod, encircling it at a little distance. By moderately heating the end of the cylinder, it will, when placed on the guttapercha, make a groove which will fix the tube, and prevent infiltration of the fluids. Line the inside of the jar with a plate of thin copper, bent into a cylindrical form, and having a few holes punched in it, through which may be threaded the extremity of another length of copper wire. On the top of this cylinder place a flat ring of copper pierced with holes, and nearly, but not quite, touching the porous cylinder. This forms the battery. To charge it, a saturated solution of copper sulphate is poured between the copper and the clay tube, and some crystals of the same salt are placed upon the perforated ring so as just to be in contact with the solution. The zinc compartment is then filled with a solution of zinc-sulphate, sal-ammoniac, or common salt. ('Electrician.')

Grove's.—(*a*) The elements of this

battery are platinum for the negative and zinc for the positive. The battery requires a containing vessel to hold the entire arrangement, and an inner cell to hold the platinum foil only. This inner cell, like that in Daniell's battery, is of porous earthenware, which will permit the passage of the galvanic current through its sides, but will not allow the exciting fluids to mingle. When the zinc plate *a* is placed in the containing jar, the porous cell is placed between the upright portions of the zinc, and the platinum foil *b* is then put into the porous cell, as in Fig. 7. The zinc plate is usually made of a long strip bent up in the form of the letter U, by which means the zinc is brought opposite to each side of the platinum plate. But it is advantageous, instead of bending a long strip of zinc, to employ 3 shorter pieces: 1 to be put at the bottom of the containing jar, and 2 others resting on this to form the vertical sides. This is expensive to make, and more economical to use. Binding-screws, attached to the zinc plate and the platinum, form the 2 electrodes. The excitants are strong nitric acid in the porous cell with the platinum, and acidulated water with the zinc. The form illustrated is most convenient on the score of portability, but the greatest power is obtained by arranging the battery in cylindrical vessels like a Bunsen. The ends and bottoms of porous cells may be thickened for strength. These batteries are expensive at first, owing to the high price of platinum; but the latter does not waste, and is best procured of reasonable stoutness at the outset. The connections may be soldered; but it is better to have a copper intermediary clamp-piece, and coat it with a protective against the acid fumes, e.g. Brunswick varnish, or an alcoholic solution of sealing-wax. The Grove battery costs about 3 times as much as a Bunsen of equal power; but its low resistance gives a stronger current for the same size. The connections and conductors must be of stout, soft copper; and the porous cells should have a lip at one corner. The duration of the battery about equals that of the Bunsen, with a smaller consumption of nitric acid.

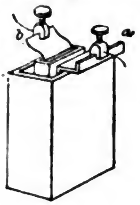

FIG. 7.

Grenet's.—A solution of 100 parts water, 10 of potash bichromate, and 10 of sulphuric acid in the porous cell, replaces the nitric acid employed by Grove and Bunsen. This battery does not emit acid fumes, but the carbon is rapidly encrusted with chromium oxide, which arrests the galvanic current.

Leclanché.—(*a*) This form of battery, Fig. 8, is in very general use for electric bells, its great recommendation being that, once charged, it retains its power without attention for several years. 2 jars are employed in its construction: the outer one is of glass, contains a zinc rod, and is charged with a solution of ammonium chloride (sal-ammoniac). The inner jar is of porous earthenware, contains a carbon plate, and is filled up with a mixture of manganese peroxide and broken gas carbon. When the carbon plate and the zinc rod are connected, a steady current of electricity is set up, the chemical reaction which takes place being as follows: The zinc becomes oxidised by the oxygen from the manganese peroxide, and is subsequently converted into zinc chloride by the action of the sal-ammoniac. After the battery has been in continuous use for some hours, the manganese

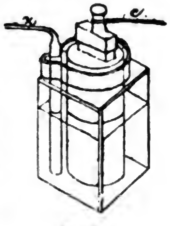

FIG. 8.

becomes exhausted of oxygen, and the force of the electrical current is greatly diminished ; but if the battery be allowed to rest for a short time, the manganese obtains a fresh supply of oxygen from the atmosphere, and is again fit for use. After about 18 months' work, the glass cell will probably require recharging with sal-ammoniac, and the zinc rod may also need renewing ; but should the porous cell get out of order, it is better to get a new one entirely, than to attempt to recharge it. (Dyer.)

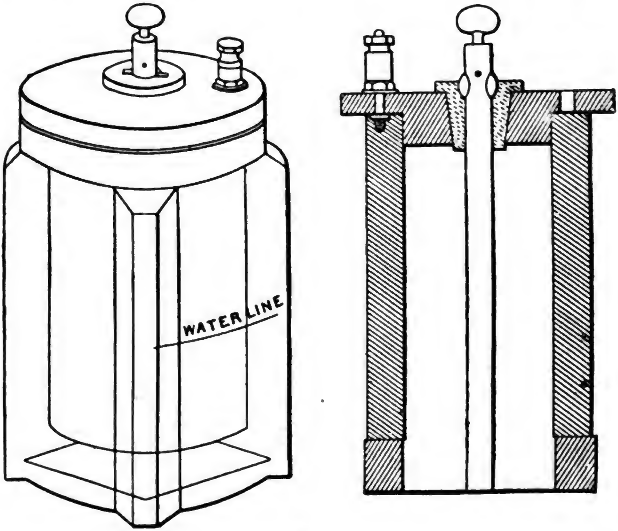

Fig. 9.

(*b*) *Modified Leclanché.*—The desire to obtain an open-circuit battery of large generating power, and one which should quickly recuperate, led to the construction of the Holtzer cylinder battery of the Leclanché type, shown in Fig. 9. As will be seen, the battery consists practically of two parts only, as the cylinder, zinc, and connector form the first part, they being collectively united and forming one piece alone ; the second part being the glass jar. The cylinder, resting on the top of the jar, forms by its weight a well-sealed joint, thus preventing evaporation. There are no fragile parts to be easily broken, but one strong heavy carbon of cylindrical form, having a binding post well secured to it and thoroughly protected from salts. The zinc is separated from the cylinder by a porcelain piece of wedge shape to secure a close fit. Thus is presented one of the simplest and most practical forms of Leclanché battery obtainable.

Marié - Davy. — Slightly damp mercury sulphate replaces the nitric acid in the porous cell of a Bunsen battery. The working expenses of this battery are very high, and it is used only in the telegraphic service, where the Daniell battery with balloons is not preferred.

Smee's. — This battery is very simple in construction. It is composed of a thick wooden frame open at the top, with three internal parallel grooves which run the height of the two opposite sides. The middle groove receives a movable plate of silver, platinum, gold, or copper which has been strongly gilt, silvered or platinised; its surfaces must be rough or with a dead lustre. Two plates of strongly amalgamated zinc are run down the other two grooves. The plates of zinc must be near to, but not in contact with, the central one, and are connected by a wire or metallic band. The positive wire starts from the middle plate, and the negative from the zinc, and the whole apparatus is immersed in a solution containing common salt or $\frac{1}{10}$ of sulphuric acid. Several elements may be united together by connecting the zinc of the first with the middle plate of the second. Or the cell may be made of gutta-percha, with a plate of carbon to replace the plate of silver, or of platinised copper. The two other grooves receive two plates of amalgamated zinc with one of the upper corners cut away. A double binding screw, for the positive wire, is fixed upon the plate of carbon where the two zinc corners have been cut off, and another large binding screw unites the two zinc plates, and carries the negative wire. Fill the cell with water saturated with common salt, or acidulated with $\frac{1}{10}$ of sulphuric acid.

Urquhart's.—A voltaic generator, based on a modification of Dr. Byrne's negative plate cells, was devised by Urquhart, and is simply a potash bichromate cell with negative plates of peculiar construction, and so arranged that a powerful current may be obtained from even 6 cells by the aid of abundant agitation.

Each negative element consists of a copper plate, to one surface of which, as well as to its edges, a sheet of compact platinum foil, free from pin-holes, is soldered, and to the opposite surface a sheet of lead—the three metals being so united that the copper is protected from the action of acids. The leaden back and edges are then coated with asphaltum varnish or an acid-proof cement; and lastly, the platinum face, being first rubbed over gently with emery cloth, is thoroughly platinised.

To effect this, fill a containing-vessel and a porous cell with acidulated water, and place the porous cell within the large vessel. Tie a strip of zinc by a clean wire to the plate to be platinised; dip the zinc in the porous cell, and the plate in the outer cell, and drop into the outer cell, while stirring, a solution of platinic chloride in water: add it drop by drop, with agitation, until the platinum surface is seen to turn dark, and to have acquired a granular deposit of platinum. Upon this surface depends to a great degree the power of the generator. If any difficulty is experienced in securing a good deposit, dip only a little of the zinc in the solution at first, and increase as the coating is seen to form. Dry carefully, and do not scratch the plate or remove the deposit, as easily happens before it is dry. Each cell contains 2 such plates, between which a single zinc is suspended; and when the elements are immersed so that the exciting fluid reaches to within 1 in. of the top, a large negative surface is brought into action. Thus the platinum alone is the negative, and the copper core is a conducting body merely; while the lead, being almost passive, serves no other purpose than to protect the copper, so that another (best, a non-metallic) substance, capable of resisting the action of bichromate solutions, might, with advantage, replace it. The exciting solution used in this cell is prepared as follows:—

Potash bichromate. . . .	2 oz.
Warm water	1 pint.
Sulphuric acid, when cool.	4 oz.

Fig. 10 represents a 6-cell generator

of this kind. The ordinary, brown, glazed earthenware, oblong cells should be capable of containing at least 1 pint of the liquid; quarts will be found more economical. There are 3 plates in each cell—2 platinised, and 1 amalgamated zinc between. They are separated at the top edges by slips of wood or ebonite, against which they are securely clamped by stout brass clamps as shown. Thus the brass clamp, being in metallic contact with the lead, with clean scraped surface represents them both as the positive pole. To the zinc plate in the centre is soldered a common binding screw. Very stout, soft copper wires, about No. 12, are used to connect the elements in series (zinc to platinum), with clean contacts. The sets of plates are fastened to a wooden framing, made to slide up and down the side uprights, by means of shaft, cords, and handle *a*, enabling the whole to be withdrawn from the excitant at one action. A ratchet and pawl keeps the plates in position. For quart cells the plates may be 8 in. long and 4½ in. wide. The air-distributing arrangements are as follow: *b*, ½-in. leaden piping, fastened to the back of the framework, whence lead 6 ¼-in. rubber tubes, extending to the bottom of the cells, and running parallel with and directly under the plate edges; their ends are closed, and the horizontal portion is abundantly perforated; *c*, rubber pipe slipped over the end of *b*, its other end being made secure to the outlet *d* of a hand-pump *e* worked by the handle *f*. A valve at *d* closes the passage to *b* when the handle is drawn up, otherwise the solution would be pumped out of the cells. The whole is screwed to the floor for steadiness. It is better to use a Fletcher's foot-blower.

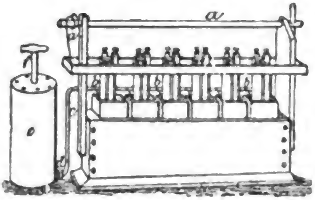

FIG. 10

If the elements are simply lowered into the solution, much greater power is obtainable from them than that given by zinc-carbon batteries. The full effect, however, can only be obtained by pumping in air by the small tubes. A great disturbance of the liquid results, and the current is so much augmented in power, that even a 6-cell battery will yield a current equal to that given by a 20-cell Bunsen or Grove. The air disturbance has no effect upon the electro-motive force of the battery, although the volume of current given off is enormously increased, and any other means of effecting the required agitation would probably answer the purpose equally well. The suggestion of Prof. Adams as to the air effecting a free circulation in the fluid, by which the metallic surfaces are kept constantly clear, is undoubtedly the correct explanation. The effects are in great part due to the low internal resistance of the cell, owing to the peculiar arrangement of negative plate, partly to the rapid flow of air upwards through the liquid, and partly to the production of heat. The action of the air flow is principally mechanical, but by hastening the combustion of the zinc it tends to generate heat, which in turn reduces the resistance. The mechanical action of the air removes from the neighbourhood of the negative plate the chrome-alum formed there, and from the surfaces of the zinc plate the zinc sulphate and brings a fresh supply of solution constantly to the surfaces.

Watt's.—In a stoneware jar holding about 4 gal., place a cylinder of thin sheet copper, dipping into water acidulated with 2 lb. sulphuric acid and 1 oz. nitric acid. A solid zinc cylinder is put into the porous cell, which is filled with a concentrated solution of common salt, to which a few drops of hydrochloric acid have been added.

ELECTRIC BELLS AND ALARMS.

(*See also* COMBINED TELEPHONES AND BELLS.)

AN ordinary electric bell is merely a vibrating contact-breaker carrying a small hammer on its spring, which hammer strikes a bell placed within its reach as long as the vibration of the spring continues. The necessary apparatus comprises a battery to supply the force, wires to conduct it, circuit-closers to apply it, and bells to give it expression.

The Leclanché battery (Fig. 11) has always been considered the best for all electric bell systems, its great recommendation being that, once charged, it retains its power without attention for a long period and, when necessary, can have its power revived quite easily. 2 jars are employed in its construction: the outer one is of glass, contains a zinc rod, and is charged with a solution of ammonium chloride (sal-ammoniac). The inner jar is of porous earthenware, contains a carbon plate, and is filled up with a mixture of manganese peroxide and broken gas carbon. When the carbon plate and the zinc rod are connected, a steady current of electricity is set up, the chemical reaction which takes place being as follows: The zinc becomes oxidised by the oxygen from the manganese peroxide, and is subsequently converted into zinc chloride by the action of the sal-ammoniac. After the battery has been in continuous use for some hours, the manganese becomes exhausted of oxygen, and the force of the electrical current is greatly diminished; but if the battery be allowed to rest for a short time, the manganese obtains a fresh supply of oxygen from the atmosphere, and is again fit for use. After about 18 months' work, the glass cell will probably require recharging with sal-ammoniac, and the zinc rod may also need renewing; but should the porous cell get out of order, it is better to get a new one entirely, than to attempt to recharge it.

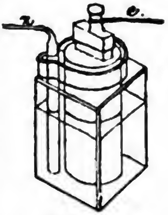

FIG. 11.

The "dry" battery has come into wide use, of late years, for many purposes and, although fulfilling a decided want, it is not likely to entirely displace the Leclanché. The latter can be so easily replenished, i.e. revived, even by an amateur, when its power fails, whereas the dry battery cannot be treated even by a local bell-fitter. Fig. 12 illustrates a well-known dry battery. It is merely a cylindrical metal shell, soundly closed each end, one end having the wire attachments shown. The compounds with which the different makes are charged is more or less a trade secret, differing to some extent in each case, but what may be considered as a typical charging is as follows: The zinc cylinder is

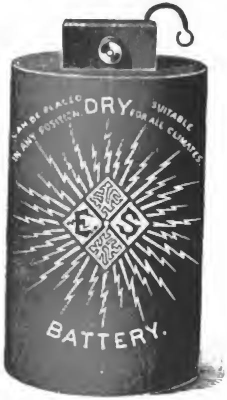

FIG. 12.

lined with a paste of zinc oxide with plaster-of-Paris. This forms a sort of internal porous pot or partition. A paste of sal-ammoniac, manganese dioxide, carbon dust, glycerine and water, is then made, and this is filled in and packed tightly round the carbon bar, or element, which is in the centre. This completes the charging and the top is then soundly fastened on.

Bell Circuits.—(*a*) For quite small purposes, one battery cell will suffice, but for general small purposes two are used, it being decidedly economical to have the battery of full power. In a 12-roomed house three cells would be best, increasing up to 4 or 6 as required. It is false economy to use a battery too weak to do its work properly. The battery should be placed where it will not be subject to changes of temperature, e.g. in an underground cellar.

The circuit wire used in England for indoor situations is "No. 20" copper wire, covered with guttapercha and cotton. In America, "No. 18, first-class, braided, cotton-covered, office wire" is recommended, though smaller and cheaper kinds are often used. The wire should be laid with great regard to keeping it from damp, and ensuring its perfect insulation. Out of doors, for carrying long distances overhead, ordinary galvanised iron wire is well adapted, the gauge running from "No. 4" to "No. 14," according to conditions. Proper insulators on poles must be provided, avoiding all contact with foreign bodies; or a rubber-covered wire encased in lead may be run underground.

The circuit-closer, or means of instantaneously completing and interrupting the circuit, is generally a simple press-button. This consists of a little cylindrical box, provided in the centre with a button, which is either (1) attached to a brass spring that is brought into contact with a brass plate at the back of the box on pressing the button, or (2) is capable of pressing together 2 springs in the box. A wire from the battery is attached to the spring of the press-button, and another from the bell is secured to the brass plate. Platinum points should be provided on the spring and plate when the contact takes place. While the button is at rest, or out, the electric circuit is broken; but on being pressed in, it completes the circuit, and the bell rings.

The relative arrangement and connection of the several parts is shown in Fig. 13: *a*, Leclanché cell; *b*, wire; *c*, press-button; *d*, bell. When the distance traversed is great, say ¼ mile, the return wire *e* may be dispensed with, and replaced by what is known as the "earth circuit," established by attaching the terminals at *f* and *g* to copper plates sunk in the ground.

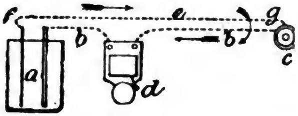

FIG. 13.

The bells used are generally vibrating ones, and those intended for internal house use need not have a higher resistance than 2 or 3 ohms. At other times, single-stroke and continuous-ringer bells have to be provided, the latter being arranged to continue ringing until specially stopped. The bell may or may not be fitted with an annunciator system (with an indicator); the latter is almost a necessity when many bells have to ring to the same place, as then 1 bell only is requisite. A single-stroke bell is simply a gong fixed to a board or frame, an electro-magnet, and an armature with a hammer at the end, arranged to strike the gong when the armature is attracted by the magnet. A vibrating bell has its armature fixed to a spring which presses against a contact-screw; the wire forming the circuit entering at one binding-screw, goes to the magnet, which in turn is connected with the armature; thence the circuit continues through the contact-screw to the other binding-screw, and out. When set in motion by electricity, the magnet attracts the armature, and the hammer strikes the bell; but in its forward motion the spring leaves the contact-screw and thus the circuit is broken; the hammer then falls back, closing the circuit again, and so the action is continued *ad libitum*, and a rapid vibratory motion is produced, which makes a ringing by the action of the successive blows of the hammer on the gong.

The following useful hints on electric bell systems are condensed from Lockwood's handy little volume on telephones.

With regard to the battery, he advises to keep the sal-ammoniac solution strong, yet not to put so much in that it cannot dissolve. Be extremely careful to have all battery connections clean, bright, and mechanically tight, and to have no leak or short circuit. The batteries should last a year without further attention, and the glass jars never ought to be filled more than ¾ full.

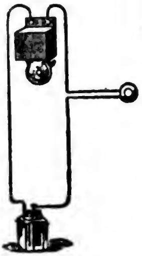

FIG. 14.

1 *Bell and* 1 *Press-button.*—The simplest system is 1 bell operated by 1 press-button as Fig. 14. The arrangement of this is the same whether the line be long or short. Set up the bell in the required place, with the gong down or up as may be chosen; fix press-button where wanted, taking all advantages offered by the plan of the house; e.g. a wall behind which is a closet is an excellent place to attach electrical fixtures, because then it is easy to run all the wires in the closets, and out of sight. Set up the battery in a convenient place, and, if possible, in an air-tight box. Calculate how much wire will be requisite, and measure it off, giving a liberal supply; joints in inside work are very objectionable, and only admissible where absolutely necessary. Cut and scrape off the insulating material from ends of wire where contact is to be made to a screw. Only 3 wires are necessary, i.e. (1) from 1 spring of the press-button to 1 pole of the battery, say the carbon, (2) from the other spring of the button to 1 binding-screw of the bell, (3) from the other pole of the battery to the other binding-screw of the bell. In stripping wires, leave no ragged threads hanging; they get caught in the binding-screw, and interfere with the connection of the parts. After stripping the wire sufficiently, make the ends not only clean but bright. Never run 2 wires under 1 staple. A button-switch should be placed in the battery-circuit, and close to the battery, so that, to avoid leakage and accidental short circuiting when the bells are not used for some time, it may be opened.

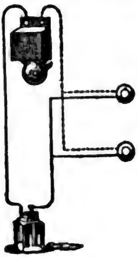

FIG. 15.

1 *Bell and* 2 *Press-buttons.*—The next system is an arrangement of 2 press-buttons in different places to ring the same bell as Fig. 15. Having fixed the bell and battery, and decided upon the positions of the two buttons, run the wires as follows: 1 long wire is run from 1 pole of the battery to 1 of the springs of the most distant press-button, and where this long wire approaches nearest to the other press-button it is stripped for about 1 in. and scraped clean; another wire also stripped at its end, is wound carefully around the bare place, and the joint made. The other end of the piece of wire thus branched on is carried over and fastened to the spring

of the second press-button. This constitutes a battery wire branching to 1 spring of each press-button. Then run a second wire from 1 of the bell binding-screws to the other spring of the most distant press-button, branching it in the same manner as the battery-wire to the other spring of the second button; connect the other pole of the battery to the second binding-screw of the bell, and the arrangement is complete—a continuous battery-circuit through the bell when either of the buttons is pressed. Before covering the joints it is well to solder them, using rosin as a flux.

2 *Bells and* 1 *Press-button.*—When it is required to have 2 bells in different places, to ring from 1 press-button at the same time, after erecting the bells, button, and battery, run a wire from the carbon pole of the battery and branch it in the manner described to 1 binding-screw of each bell; run a second wire from the zinc pole of the battery to 1 spring of the button, and a third wire from the other spring, branching it to the remaining binding-screw of both bells. It will not answer to connect 2 or more vibrating bells in circuit one after another, as the 2 circuit-breakers will not work in unison; they must always be branched, i.e. a portion of the main wire must be stripped, and another piece spliced to it, so as to make 2 ends.

Continuous Ringing Bells.—Fig. 16 shows the method of connecting up a continuous ringing bell, which can be converted to an ordinary bell by means of the switch S.

Fig. 17 shows a simple means of converting an ordinary electric bell into a continuous ringer. First provide the third binding-screw shown. The armature requires two springs *a* and *b*, the latter is in contact with the pillar B until the current passes, but the spring *a* is not in contact with the pillar A by a space of about $\frac{1}{16}$ in. The push marked C is a "reverse" push which breaks contact instead of making it. When the push D, which is of the ordinary kind is used the bell rings and the armature in springing from the magnet, bends *b* a little so that the spring *a* touches the pillar A. This short-circuits the current through the middle binding-screw and the current is then continuous until the push C is used and breaks the contact.

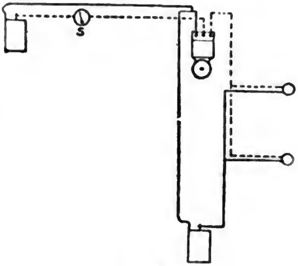

FIG. 16.

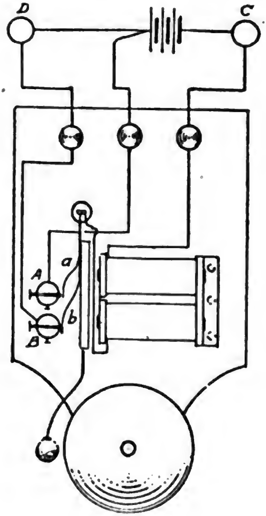

FIG. 17.

There are other methods one of which is, if more than 1 bell is designed to ring steadily when the button is pressed, to let only 1 of the series be a vibrating-bell, and the others single-strokes; these, if properly set up and adjusted, will continuously ring, because they are controlled by the rapid make and break of the 1 vibrator.

Annunciator System.—To connect an indicating annunciator of any number of drops with a common bell, to be operated by press-buttons in different parts of a house, is a handy arrangement, as one drop may be operated from the front door, another from the drawing-room, a third from the dining-room and so on. The annunciator (indicator) is fastened up with the bell near it as Fig. 18. All the electro-magnets in the annunciator are connected by one wire with one binding-screw of the bell and the other binding-screw of the bell is connected with the zinc of the battery. It is a good plan to run a wire through the building from top to bottom, at one end connecting it with the carbon pole of the battery. It ought to be covered with a different coloured cotton from any other, so as to be readily identified as the wire from the carbon. Supposing there are 6 press-buttons, one in each room, run a wire from one of the springs of each of the press-buttons to the main wire from the carbon pole, and at the point of meeting strip the covering from both the main wire and the ends of the branch wires from the press-buttons, and fasten each branch wire to the main wire, virtually bringing the carbon pole of the battery into every press-button. Next, lead a second wire from the other spring of each press-button to the annunciator screw-post belonging to the special drop desired. This will complete the circuit when any of the press-buttons is pushed; for, as each annunciator magnet is connected on one side to its own press-button, and on the other side to the common bell, it follows that when any button is pressed, the line of the current is from the carbon pole of the battery, through the points of the press-button, back to the annunciator, thence through the bell to the zinc pole of the battery, and that, therefore, the right annunciator must drop and the bell must ring. In handsome houses, run the wires under the floor as much as possible, also test each wire separately, as soon as the connection is made.

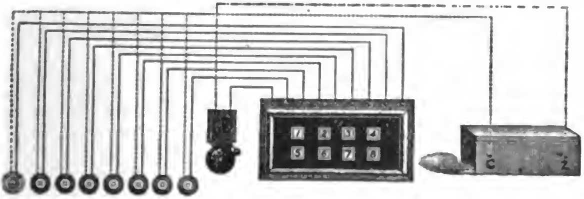

FIG. 18.

Double System.—A system of bells in which the signalling is done both ways, that is, in addition to the annunciator and bell located at one point, to be signalled by pressing the button in each room, a bell is likewise placed in each room, or in a certain room, whereon a return signal may be received—transmitted from a press-button near the annunciator. This is a double system, and involves additional wires. One battery may furnish all the current. Run the main carbon wire through the house, as before, in such a manner as to admit of branch wires being easily attached to it. Run a branch wire from it to the spring of one of the press-buttons, a second wire from the other spring of the same button to the screw post of the bell in room No. 2, and from the other screw-post of the said bell to the zinc-pole of the battery. This completes one circuit. The other is then arranged as follows: The main carbon, besides being led, as already described, to the spring of the press-button in room No. 1, is continued to one of the binding-screws of the bell in the same room; the other terminal of that bell is carried to one spring of the press-button in room No. 2; the complementary spring of that press-button is then connected by a special and separate wire with the zinc of the battery, and the second circuit is then also completed.

An alternative method is to run branches from the main carbon wire to all the press-buttons, and from the main zinc wire to all the bells, connecting by separate wires the remaining bell terminals with the remaining press-button springs. In the latter plan, more wires are necessary. Although the connections of but one bell either way have been described, every addition must be carried out on the same principle.

Other Methods.—(1) When 2 points at some distance from one another, e.g. the house and a stable 100 yd. distant, are to be connected, it is easy to run 1 wire, and use an earth return. If gas or water pipes are in use at both points, no difficulty will be found in accomplishing this. A strap key will in this case be found advantageous as a substitute for a press-button. The connecting wire at each end is fastened to the stem of the key; the back contact or bridge of the key, against which when at rest the key presses, is connected at each end with 1 terminal of the bell, the other terminal of each bell being connected by wire with the ground. A sufficient amount of battery is placed at each point, and 1 pole of each battery is connected with the earth, the other pole being attached to the front contact of the strap key. If impossible to get a ground, the second terminal of both bell and battery at each end must be connected by a return wire.

(2) It is possible to ring 2 bells with only 1 wire by having 2 series of cells: but this involves much more expense and trouble than laying a double wire and one series of cells. You can work with 1 wire if you allow both bells to ring at the same time, and have a battery at each end, or you can so arrange the batteries and bells as to throw battery of one end in circuit with the bell of the other end, and so on, as in Fig. 19, where *a* represents the gas-pipe; *b*, line wire joined up with bells in circuit: *c* and *d*, 2 wires going through cells and on to pushes in connection with line wire. Thus, when either of the pushes is closed down, the battery and distant cell are in circuit, and *vice versâ*.

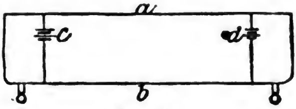

FIG. 19.

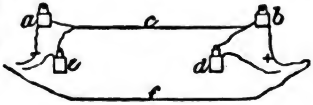

FIG. 20.

(3) The subjoined arrangement (Fig. 20) is a simple way of effecting the same object as the preceding. Let *a b* be bells at shop and house respectively; connect the line wire *c* with a binding-screw of each bell, as shown. Have a battery at shop and another at house, *d* and *e*; connect line-wire also with one pole of each battery; connect the remaining binding-screw of each bell with a metallic plate; connect the remaining poles of batteries, each with a metallic plate. Instead of the ordinary "push," arrange metallic

springs at shop and house, permanently connected with gas-pipe *f*, and so placed that when at rest they are in contact with the plates.

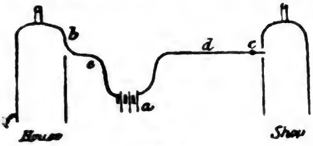

FIG. 21.

(4) Fig. 21 shows another solution of the same difficulty. The battery *a* is placed in the house. At *b* and *c* are 2 small levers, which can be moved so as to put the line wire *d*, and the short wire *e*, which constitute the poles of the battery, in connection with the earth in 2 sets of ways. The figure shows the connection in case it is wished to ring the house bell from the shop. Before leaving the house, bring the lever *b* in connection with the wire which traverses the electro-magnet of the house bell; thus *e* is brought into connection with the earth at *f*. Whenever, then, in the shop, you press down the lever *c*, you complete the circuit, and the house bell rings. Before leaving the shop, raise the lever *c* so as to bring the shop bell into the circuit, and when returning to the house you can complete the circuit, and cause the shop bell to ring every time you press down the lever *b*.

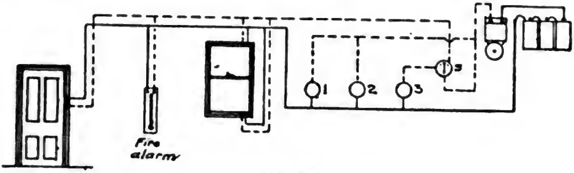

FIG 22.

(5) Fig. 22 shows a bell system in which there are three pushes, two burglar-alarms and one fire alarm, all operated by one battery and actuating one bell. The push 3 and the alarms cannot both be used at once, the switch shown preventing this, but the pushes 1 and 2 can be used day or night. Thus all pushes can be used in the day time without any annoyance being caused by the alarm operating when door or window is opened; then the alarms can be thrown into circuit at night. If desired the switch could be arranged that all pushes might be used day or night, the push 3 only being shown cut out in this instance to indicate how such a thing can be done if desired.

Fig. 23 shows a special method of operating two bells. There are one ordinary push and two "Morse" pushes. Push 1 rings both bells, push 2 rings bell A, and push 3 rings bell B. Morse pushes are essential if only one battery is to be used.

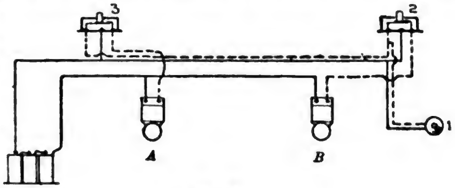

FIG. 23.

(6) The Leclanché battery cell is made in three sizes, viz. No. 1 (smallest), 2 and 3 (largest), but the latter is not sufficient by itself for an installation where there is a run of 25 yards of wire each way to the furthest push, even if the bell be a small one. For hotels and institutions six No. 3 cells may be needed, and let it be remembered that money is spent particularly well in having full battery power. The method of connecting the cells together to form a battery is as Fig. 24, and this holds good however many cells there may be. Having connected and placed the battery in position, each jar is given its charge of sal-ammoniac, and water added to fill it three-parts full. The battery should be kept in a *cool* place (not on the top shelf of a kitchen) to prevent a peculiar creeping of the salts over the edge of the jar. The creeping, however, can generally be stopped by giving the inside of the jar a coat of melted paraffin wax, or tallow, above the water line. The No. 1 cell is of little use except to form a battery, and No. 2 can only be put to work a small bell a short distance by itself. When the cells weaken, a little more water is sometimes sufficient to revive the battery; if not, then a fresh charge of sal-ammoniac will nearly always suffice, and let the zincs be scraped clean at the same time. It is a good plan to amalgamate the zinc rods after scraping. This is done by putting them in dilute sulphuric acid to clean, and then rubbing a little mercury (quicksilver) over them.

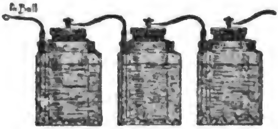

FIG. 24.

For cheap work of moderate size No. 22 wire is thick enough, but for better residence work No. 20 should be used. No. 18 is best for larger works if the price is not cut too low. The ordinary rubber and cotton covered wire acts well, but in a large system of wires with an indicator, then the wire which has so many joints on it might well be gutta-percha covered, as this facilitates the proper re-covering of the wire where the joints come. Joints are made by uncovering the ends of the wires about an inch, then scraping them perfectly clean with a knife (without nicking the wire); afterwards they are twisted closely together, soldered, and finally covered. Resin should be the flux used in soldering. The zinc rod is connected direct with the bell, while the carbon is connected with the push. Fig. 25 shows how connections are made with several pushes (just like flow and return branches of a hot water circulation). Fig. 26 gives the connection for ringing two (or three) bells from one push. The bells can be a distance apart. Fig. 27 shows the wiring of a bell to a servant's bedroom, which will ring continuously until she gets out of bed, and switches it off. It will be seen that a switch is used in place of a push

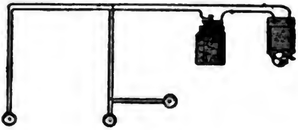

FIG. 25.

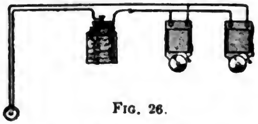

FIG. 26.

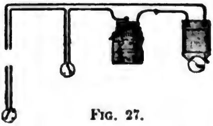

FIG. 27.

in this instance. Fig. 28 is the wiring to a bell which is a long distance from the push, in which case no return wire is used, but an earth return is substituted. It is not usually necessary to carry wires terminating with plates in the earth as shown; it can generally be arranged to connect these wires on to water or gas mains, these being good conductors and going to earth as a matter of course. Fig. 29 illustrates the connections where an indicator is introduced, as is usually necessary in all cases where several pushes operate one bell.

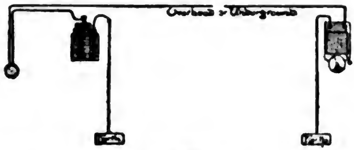

FIG. 28.

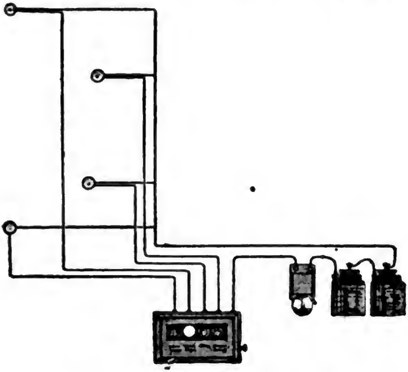

FIG. 29.

Making an Electric Bell.—The following description applies to 3 sizes—viz. for a 2-in. bell, hereafter called No. 1; 2¾-in. or No. 2; 4-in., or No. 3, which sizes are sufficient for most amateurs' purposes, and, if properly made, a No. 3 Leclanché cell will ring the largest 2 through over 100 yd. No. 24 (B. W. G.) wire.

The Backboard and Cover.—This may be of any hard wood, by preference teak, oak, or mahogany, and if polished, so much the better; the size required will be—

No. 1, 5¼ in. long, 3¾ in. wide, ½ in. thick.
No. 2, 7 in. ,, 3¾ in. ,, ¾ in. ,,
No. 3, 8¼ in. ,, 5 in. ,, ¾ in. ,,

The cover must be deep enough to cover all the work, and reach to within about ¼ in. of the top and sides of back, and allow ⅜ in. to ¾ in. between the edge of bell and cover; the making of this had better be deferred until the bell is nearly complete.

The Electro-Magnet.—This should be of good round iron, and bent into a horse-shoe shape (Fig. 30). The part *a b* must be quite straight, and not damaged by the forging; the bend should be as flat as possible, so as to make the magnet as short as may be (to save space). When made, the magnet is put into a clear fire, and when red hot, taken out and laid in the ashes to slowly cool; care must be taken not to burn it. Lastly, 2 small holes are drilled in the centre of

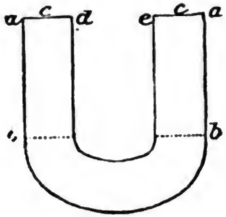

FIG. 30.

the ends at *c*, about $\frac{1}{16}$ in. deep; drive a piece of brass wire tightly into the holes, and allow the wire to project sufficiently to allow a piece of thin paper between the iron and the table when the iron is standing upon it; this is to prevent the armature adhering to the magnet from residuary magnetism, which always exists more or less. The measurements are—

No. 1 size iron ¼ in., *d* to *e* ⅜ in., *a* to *b* 1¼ in.
No. 2 ,, $\frac{5}{16}$ in., ,, ½ in., ,, 1⅜ in.
No. 3 ,, $\frac{7}{16}$ in., ,, ⅝ in., ,, 1½ in.

The Bobbins or Coils. — These are made by bending thin sheet copper round the part *a b* of the magnet; the edges at *a* (Fig. 31) must not quite meet. The thickness of this copper must be such that 4 pieces just equal in thickness the edge of a new threepenny-piece (this is rather an original gauge, but then all can get at the thickness this way). The hole in the brass end *b* must be just large enough to push on firmly over the copper when on the iron; they must then be set true, and soldered on. The brass for the ends may be about as thick as a sixpence; a $\frac{1}{16}$-in. hole must be drilled at *c*, close to the copper. The other measurements are as follows:—

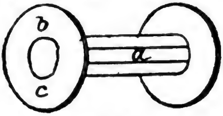

FIG. 31.

No. 1, diameter ⅝ in., length over all 1¼ in.
No. 2, ,, ¾ in., ,, 1½ in.
No. 3, ,, 1 in., ,, 1¾ in.

The brass ends should be neatly turned true, and lacquered.

Winding Bobbins.—For this purpose, No. 28 wire should be used, which is better if varnished or paraffined. The bobbins should be neatly covered with paper over the copper tube and inside of ends, to prevent any possibility of the wire touching the bobbin itself; the bobbin is best filled by chucking it on a mandrel in the lathe, or a primitive winding apparatus may be made by boring a hole through the sides of a small box, fit a wire crank and wooden axle to this, and push the bobbin on the projecting end—thus (Fig. 32): *a*, crank; *b*, box; *c*, bobbin; *d*, axle. The box may be loaded to keep it steady; on no account attempt to wind the wire on by hand—the bobbin must revolve. Leave about 1½ in. of wire projecting outside the hole *d*, in end of bobbin, and wind the wire on carefully and quite evenly, the number of layers being respectively 6, 8, and 10; the last layer must finish at the same end as the first began, and is best fastened off by a silk or thread binding, leaving about a 3-in. piece projecting. Both bobbins must be wound in the same direction, turning the crank from you, and commencing at the end nearest the box. The bobbins must now be firmly pushed on the part *a b* of the magnet, and the two pieces of wire projecting through the holes *c* soldered together.

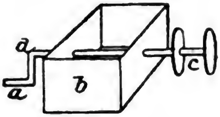

FIG. 32.

Assembling Part.—First screw on the bell. This should be supported underneath by a piece of ¼-in. iron tube, long enough to keep the edge of the bell ⅜ to ⅝ in. above the backboard. Cut off the hammer-rod, so that when the head is on it will come nearly as low as the bell screw, and in a line with it. Make a hole in the backboard, and drive the armature post in tightly —it must be driven in so far that when the magnet is laid upon the backboard, the centre of the magnet iron and the armature are the same height. Place the magnet so that when the armature is pressed against it, the hammer-head all but touches the bell; screw it into its place by a wooden bridge across the screw passing between the bobbins. By afterwards easing this screw, any little adjustment can be made. The armature spring should tend to throw the hammer-head about ⅜ in. from the bell. The contact-post should be so placed that when the armature touches the magnet, there is a slight space between the platinum point on the screw and the platinum on the spring. In putting in the posts, a piece of copper wire must be driven in with them to attach the wire to. One post can be moved round a little either way to alter the tension of the spring; the screw in the other post can be turned in or out, to just allow the proper break to take place. By screwing it in and out, the ear will soon judge where the bell rings best. (Volk.)

General Particulars. — (1) The amounts and sizes of silk-covered wire to be used for making coils for electric bells are as follows, the number of inches indicating the diameters of the respective gongs: For a 2-in. gong, 8 yd. of No. 26; 2½-in., 9 yd. No. 26; 3-in., 10 yd. No. 26; 3½-in., 10 yd. No. 26; 4-in., 11 yd. No. 24; 5-in., 12 yd. No. 22; 6-in., 13 yd. No. 20. (2) The bells after being turned and polished receive an electro deposit of nickel or silver, or they may be warmed and lacquered with gold-lacquer in the lathe; screws and other brass fittings are done the same way. (3) It is immaterial whether the bell support be of iron or brass. (4) For winding the bobbins quickly and neatly, have a steel spindle, about ¼ in. diameter, fixed in 2 bearings on uprights on a stand. Cut 2 pieces of stout brass tube (⅜-in. common tube) each 1 in. long; turn each down taper to one end, and put a set-screw in each; then slide them over the ¼-in. spindle, so that their thin ends are nearest together. Reels with holes of many different sizes can thus easily be fixed true and wound very easily, either in the lathe, or by hand by means of a small crank.

(4) *Single-stroke Bell.*—Fig. 33 explains its construction. Instead of having a contact-breaker fixed at *a*, the circuit only goes through the magnet, thus only ringing when the button is pressed. *b* and *c* are connected with the battery.

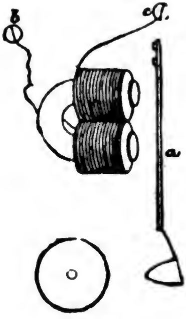

FIG. 33.

(8) *Continuous-ringing Bell.*—This is more complicated than the single-stroke, as will be seen by Fig. 34. A small piece of brass or iron is fixed in a suitable way (riveting is best) on

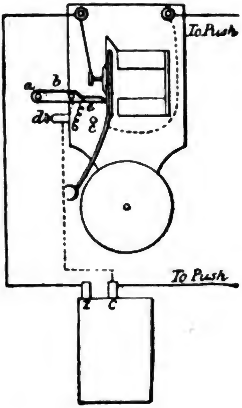

FIG. 34.

to the armature of the bell upon which rests edgeways a piece of flat brass *a*, shaped as in the diagram; it is supported by a piece of brass tube, through which a screw *b* passes, securing it to the board—not too tightly, however, so as to allow of its swinging easily; a piece of brass rod or stout wire *c* is driven into the base-board in such a way that when *a* is drawn down by the spring *e*, a good contact is formed between *a* and *c*. A wire is taken from *c* to one binding-screw of the bell, and a wire is taken from the brass tube which supports *a* to another separate binding-screw *d*. The dotted lines represent wires as well as the other lines; the dotted lines also represent the direction of the current for the continuous action, using the same wire to the zinc element. The current passes from the zinc to the contact-screw, through the coils to *c*, across *a*, down *b*, and out through the binding-screw *d* to the carbon element. The bell is stopped by pulling a cord attached to *a*, which breaks the contact, and which, if pulled hard enough, forces the armature towards the magnet by rubbing against the piece in the armature (which must be made in the shape of the diagram). When it gets above the piece in the armature, the armature springs back, and *a* rests on the piece of brass again, ready for another time.

(9) *Method of producing continuous ringing from an ordinary Electric Bell.*—The method works well, is inexpensive, and any one with ordinary intelligence could make and fix one for himself. Of course, the bell must have a contact breaker. In Fig 35, *a* is the bell; *b*, hammer, in the centre of which is screwed or soldered a piece of metal projecting outwards $\frac{1}{2}$ in. The head of hammer is flat, circular, with a hole in centre; *c*, piece of brass hung loosely on the screw, to which wire is attached, leading to bell as shown; *d*, screw and wire attached, leading to battery. On the bell being rung, the oblong piece of brass *c* is liberated, falling on to *d*, making a new circuit, producing continuous ringing until *c* is lifted up. (J. W. Fisher.)

Attending to Leclanché Battery Cells. (*a*) When, after a reasonably long period, the bells cease to ring, it is most probable that the battery needs attention. After a summer, particularly a hot, dry one, it may be found that the outer glass jars have scarcely any liquid in them. In most cases it then proves sufficient if plain water is poured into the jars to half fill them. The bells will then ring strong again for a good time. (*b*) If the glass jars appear to have sufficient liquid in them, and yet the bells do not ring, it is probable that the addition of a little sal-ammoniac will suffice. Only a small quantity need be put as no good is effected, rather the reverse, by putting more crystals in than will dissolve.

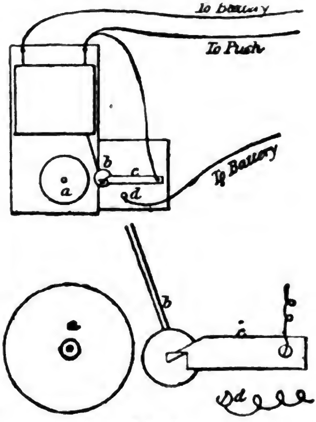

FIG. 35.

A difficulty with the Leclanché battery is that the sal-ammoniac solution rises by capillarity, and attacks the leaden taps, brass binding-screws, and wires. The following suggestions relate to batteries: (*c*) Take your battery to pieces, well wash in hot water, dry, and give a good coating of Brunswick-black; after setting up, give another, so as to thoroughly protect the leaden caps. (*d*) Try a few drops of sweet-oil on the surface of solution, to prevent verdigris on binding-screws. Try a chloride of zinc battery instead of a Leclanché. A 4-cell bichromate form battery, with sal-ammoniac solution, can be used for bells with great success and no trouble. (*e*) Avoid brass-work on Leclanché cells; use lead connections covered with Brunswick-black or black Japan varnish, which prevents salts from creeping up and destroying the connections. A Leclanché set of 6 cells will work for nearly 3 years on a bell circuit by simply refilling with water occasionally. (*f*) Take out the carbons, well soak the heads in melted paraffin for say 2 in. down, then, by reheating carbons, drive back the paraffin for sufficient space for binding-screws to take on; the paraffin wax will prevent the creeping action of the excitant. (*g*) When you put the zinc rod into the solution (which should be only half up the outer jar), see that it is well amalgamated, and do not let it touch the porous cell. (*h*) To prevent the salt and water creeping up, grease the upper portions of the carbon, zinc, and jars; to check evaporation, place your cells in a wooden case, and screw on the front so as to be air-tight. When so fitted, if the insulation is good, Leclanché batteries of the best make will work well without any attention for several years; one set of working house-bells has been in daily use for 9½ years, during which time it has been filled up with cold water 5 times, and been recharged once. Neat'sfoot-oil is the best kind of grease for this purpose. (*i*) As to the zinc connection, do not use a binding-screw at all near the cell, drill the zinc, and insert a tinned iron wire, or twist it round the rod and well solder it, then warm, as you do the carbon, and coat with the Brunswick-black. Do all connections with binding-screws fixed to a frame, say 10 or 12 in. away from the cells, where the fumes cannot well reach them. Do not wet the carbons or zincs when putting the solution in—i.e. that portion which is not intended to be in—and do not fill the jars above ¾ full.

Electric Bell-alarms and Tell-tales.—The electric current is eminently suited for alarms, tell-tales and time-signals. Mechanical telltales and similar appliances cannot be made to operate for any considerable distance while bends and turns all present difficulties. These drawbacks are quite overcome by the electric current.

Alarm for Door or Window.—In Fig. 36, *a* is a small piece of brass tubing, having a brass disc *b*, soldered on to one end of it. This is drilled and countersunk for screws, as at *c*; *d* is a small brass knob, either screwed or soldered on to the brass rod *f*, and protruding about half-way through a hole in the disc *b*; *e* is a circular disc of ebony fitting into the tube *d*, and having a hole through its centre to allow *f* to slide freely. The ebony is held in its place by screws. To one end of the ebony disc is fitted a brass circle *j*, of rather smaller diameter than *e*, also having a central hole to admit of *f* sliding. *h* is a spiral spring,

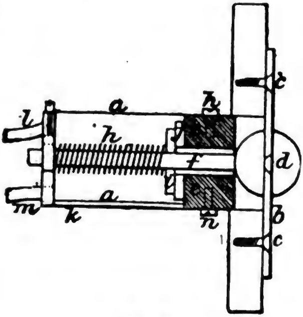

FIG. 36.

which keeps the brass cross piece *i* (passing through a hole in *f*) in contact with the brass circle *j*. *k* is a brass disc closing the end of the tube, and also allowing *f* to slide. One wire *l* is attached to this; the other wire *m* passes through a hole in *k*, and is attached to the brass circle *j*. On pressure being applied to *d*, the points of contact are forced apart and no current can pass. Immediately, however, on the pressure being removed (as by opening a door or window), the spring recovers itself, and brings the cross-piece into connection with *g*, thus closing the contact. These contact-makers are sunk in the lintel of the door or in the groove of the window, as shown in the figure. One of these must be used for each door or window to be guarded. The wires *l* and *m* should be guttapercha-covered, as, in fact, all wires used in this job should be. The rest of your work is comparatively easy. You must have an indicator in your bedroom to show which room is attacked. This will be precisely similar to those used in ordinary electric-bell work. At some point in the battery wire which goes to the indicator, you may insert an interrupter or switch, which is merely a brass arm pivoted at one end and resting on a brass stud at the other. When you desire to throw the arrangement out of gear, you have only to remove the arm from the stud.

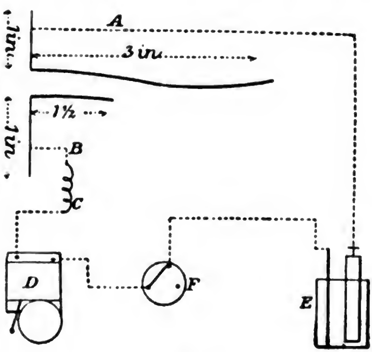

FIG. 37.

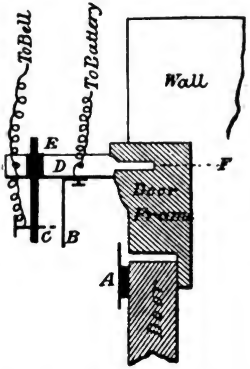

FIG. 38.

Alarm to ring while Door is being opened.—(*a*) Fig. 37. A is a spring of hard brass about $\frac{1}{16}$ in. thick and 1 in. wide, fixed on to architrave moulding of door frame; B is a similar spring fixed on to door; the connections are shown, C being short helix where the door hinges, to prevent the wire breaking; D, bell; E, battery; F, switch to cut off when not wanted.

(*b*) Fig. 38. A is a piece of wood or metal screwed on to door. D is made of wooden bar let into the door frame at top right-hand corner, supports a wooden rod E which carries the brass screw C. B is a piece of watch or small clock spring bent, and then hardened at a right angle; a hole is drilled (or punched) while soft, and the spring, well brightened, is screwed on to the block as shown. When the door is opened, A presses the spring B against the screw C, and when returning to its place A presses B away from C. Thus the bell will only ring when door is being opened. The block may be 6 in. long, and A may be made of steel spring, which gives longer contact.

Closed-circuit Burglar Alarms.—The closed-circuit system is one that provides against interruption by cutting the wires, so that if wires are cut or broken, the alarm bell is put into circuit and rings. The contacts at doors and windows are arranged in a reverse way to that usually done, for instead of the parts being brought into contact when a door or window is opened, they keep the circuit closed while the door or window remains closed and break the circuit when they are opened. The alarm circuit is kept open by the use of a small electromagnet, the armature of this being held back by a slight current from a constant gravity battery of the Daniell type. On opening a window or door, or on cutting or breaking a wire the armature of the magnet is released and this, of course, closes the alarm circuit. This alarm circuit is of the ordinary kind with Leclanché battery. The bell is usually put in the bedroom, it being only likely to have night use, and should be switched off during the day.

Electric Tell-tales for Cisterns.—(1) In Fig. 39, *a* is the tank, *b* the float, *c* V-wheels, *d* light wire rope, *e* counterbalancing weight (which must be adjusted so as not to prevent the float *b* falling with the water), *f* eye (through which the wire rope passes), fixed on arm, which, being pivoted at *g*, is kept against the stop *h* by spiral spring *k* until the stop *l*, fixed on the wire rope, is brought in contact with *f* by the rising water, when the weight *e* pulls the arm over to *i*, which brings the bell into circuit. By moving the stop *l*, the bell can be caused to ring at any level of the water, and by having another contact at *h*, and bell, and also a stop on the other side of *f*, the bell will ring when the tank is empty. When 2 bells are fitted up, the arm must be arranged to remain between the contacts, when not acted upon by the stops on the wire rope. An indicator and scale attached to the weight *e* will show the height of water in the tank.

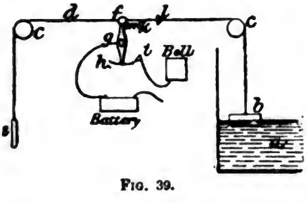

FIG. 39.

(2) In Fig. 40, *a* is the tank, the height of the water being at *b*; *c* is a tin float attached to the end of an iron rod *d*, moving on a hinge at *e*. *f* is a metal stud tipped with platinum. A small piece of platinum is also soldered on to the point on the rod *d*, opposite to *f*. *g* is a wooden support to which *e* and *f* are fastened. A wire from *f* is carried to the battery *h*, which consists of a few Leclanché cells. The other terminal of the battery goes to one of the binding-screws of the electric bell *i*; the other binding-screw is connected by a wire to *e*, but care should be taken to have this wire in good *metallic* connection with the rod *d*.

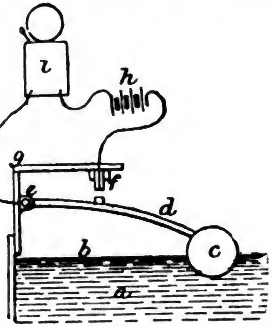

FIG. 40.

When the water rises to a certain height, the points at *f* will be put in contact, which completes the electric circuit and sets the bell ringing. The bell would cost about 4*s*. or 5*s*. ; the batteries about 3*s*. each.

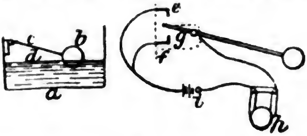

FIG. 41.

(3) In Fig. 41, *a* is the cistern ; *b*, a float ; *c*, the contact maker ; *d*, a projection to hold float. The right half of the figure shows the contact-maker. *e* is a brass stud in contact with the line wire and *f* is another stud also connected with the same wire. *g* is a piece of brass spring with the other wire attached to it ; *h* is an electric bell, and *i* the battery. Platinise all contact points. The action is as follows : When the cistern is full, the brass spring *g* touches *f*, and the bell rings. When the cistern is empty, the spring *g* touches *e*, and thus completes the circuit. It will be found very useful to employ a switch, so that when the cistern is full, the circuit can be broken, and thus save your battery. The same can be done when it is empty.

(4) Messrs. Gent and Co., Ltd., of Leicester, say that the simplest water-level alarm system, consists of a float which operates a contact or contacts, an alarm bell, a switch, and a battery, shown in outline by Fig. 42.

When the water reaches a pre-arranged height or depth, the contact closes, completing the circuit, the bell rings, and the attendant is called, who switches the bell out of circuit.

The objection to this simple system is that the attendant forgets to switch on the bell again, when the water-level has altered, and until he does so the system is out of use. To guard against this neglect a special water-level alarm annunciator has been designed. This has two sliding-rods with knobs, the higher knob for replacing the indicator flag, and the lower one for controlling the bell. The action is as follows :—

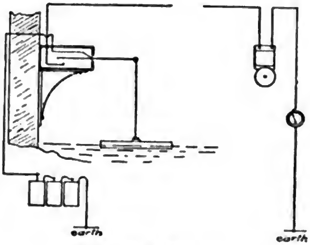

FIG. 42.

On the tank becoming say full, contact is made at the reservoir, the drop movement of the indicator falls, and the bell rings. By pressing the lower knob the bell is switched off, but the indicator signal cannot be replaced by pressing the upper knob, until the water falls in tank, and contact is broken. Any attempt to replace the signal before the water has thus fallen only results in the bell commencing to ring again, and continuing so to do, till again stopped by the lower knob.

To indicate "high" and "low," two signals are needed as shown by Fig. 43, but annunciators with only one signal are supplied to indicate "high" only, and "low" only.

It will be seen from the diagrams that where two signals are employed two lines are run between the tank and indicator, and where one signal only is needed, one line suffices.

Where the distance between the tank and indicator is great, it is possible to arrange for one line to carry both signals by the use of a polarised relay fixed in the indicator.

(5) In Figs. 44, 45, and 46, the wheel *a* is actuated by the float, and when revolving, causes the bar carrying the contact-pins to rock on its centre *b*, thus producing a circuit on one side or the

other by immersing the pins *c* in the mercury *e*, the pendulum *d* bringing the bar into its normal position. The pins are shown in a line for the sake of clearness, but they can be placed anyhow, so long as they dip together. By using mercury, you will make a great deal better contact than you can with solid metals, but the pins on the bar and the connections must be well insulated. For the recording instrument you will require a couple of ratchet wheels of equal size, but fastened together a little apart, and mounted on a common centre. You must have as many teeth on them as your float-wheel has pins, and the teeth must be cut in an opposite direction to one another, so that when the electro-magnet *g* attracts the armature and escapement *f* toward the pole marked S, the wheel at the back re-

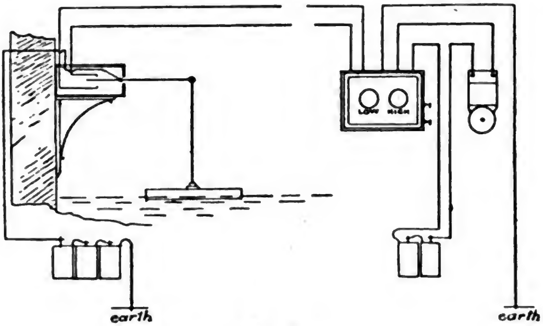

FIG. 43.

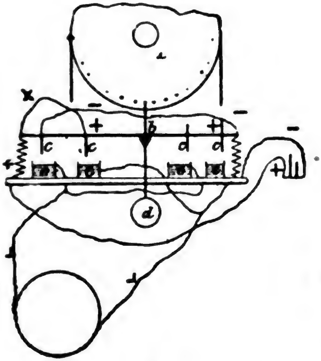

FIG. 44.

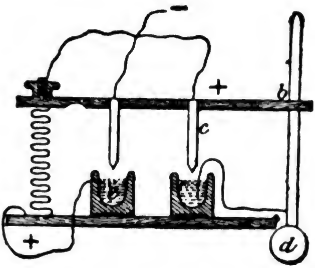

FIG. 45.

volves in the direction of the arrow (and with it the wheel and index that are shown); the reverse action takes place when armature, etc., is drawn towards N. There are several disadvantages in this plan—viz. the necessity of having the batteries at the reservoir, the liability of the instrument to get out of step, and the continuous action if the pins on the float-wheel should happen to hold the bar down.

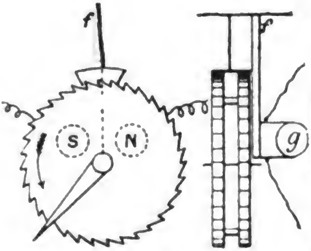

FIG 46.

(6) Fig. 47 shows an arrangement for signalling both high and low water levels: *a*, upright guide-rod firmly fixed to bottom of tank; *b*, hollow copper ball, with tube through it to slide over *a*; *c*, cap or tube with flange to slide over *a* at lower end, and attached at top end to *d*, lever arm mounted on spiral spring *e*, the centre of which is fixed to a rigid square pin; *f g*, 2 ends of a brass plate, projecting from a support at right angles to *d*; *h*, a light chain, connecting *c* and *b*, the length of which regulates the water-levels at which the bell will ring; *i k*, terminal wires, attached respectively to *f* and *e*. At low-water level the weight of *b* will bring *e* into contact with *g*; at high level, its buoyancy will bring *e* into contact with *f*.

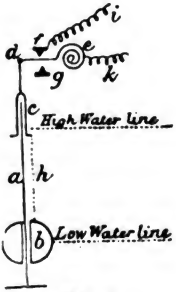

FIG. 47.

(7) In Fig. 48, *a* is a wooden frame; *b*, contact-lever; *c*, hinge to contact-lever; *d*, brass contact-screw; *e*, counter-weight and stop to prevent weight from passing through lever; *f*, float; *g*, stop for same; *h*, piece of tin for *d* to contract on; carry wire to contact-screw, as shown in sketch, along the lever. When the water gets below a certain point, it would leave the float suspended, which should by the counter-weight *e* lift the contact-lever at *i*, and make contact at *d h*. On the contrary, the float *f* should lift lever at *k*, and again make contact at *b h*. To ensure success, the float should be as heavy as possible, the lever as light, and the counter-weight heavy enough to lift the lever. The holes in contact-lever should be large enough to clear rope or chain. Pulley should not be less than 5 or 6 in. in diameter.

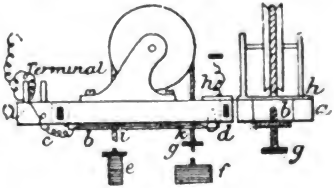

FIG. 48.

Electric Time Signals.—(1) Fig. 49 shows a simple means of making an ordinary metal alarm clock ring one or more bells at any required distance, or in any other room of the house. The clock is stood (or better still, secured) on a base-board, and this board has a wooden rod or peg soundly glued in it, about $\frac{5}{16}$ in. thick, and standing upright as shown. A brass or copper nut is obtained that will slip on the wood rod quite easily. To the top of the nut solder a piece of bell wire, this wire being formed into a loose open spring to admit of the nut dropping down the rod freely. This wire is connected to the carbon of the battery. At the base of the rod, on the base-board, fasten down a piece of sheet brass, copper, or tin, letting it come up close against the rod (or surrounding it), so that the nut, when it falls, will fall on this and complete the circuit. Solder a wire to this piece of sheet metal and take it—the wire—to the bell. From the bell to the zinc of the battery a wire is carried in the usual way. The winding key of the clock, the key which winds the alarm, must be soldered so that it does not drop down, but always stands out flat and straight. Having set and wound the alarm of the clock, let the last turn of the winding key leave it horizontal as shown. Now put the nut on the wood rod, so that it rests on the winding key. When the alarm goes off the winding key commences to revolve and, in so doing, it first lifts the nut a little then lets it drop on to the metal plate below, and this, as will be understood, completes the circuit and sets the bells ringing. The bells continue to ring until the nut is lifted, or until they are switched off by independent switches. It will be noticed that this arrangment in no way interferes with the time-piece doing its customary duty as an alarm clock for the room it is in.

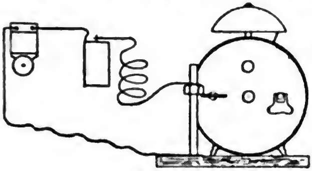

FIG. 49.

(2) To ring at 6 o'clock. Fig. 50 shows a small clock *a*, with which to work the bell; *b*, battery consisting of two Leclanché cells; *c*, disc, with a notch cut in it, running out to the diameter of the disc, and having a groove in it in which *d*, a small piece of wire, runs; attached to *d* is a small strip of sheet copper *e*, and fixed to it is the gong *f*. Set the small point in *c* to the hour required for the alarm to ring, and it will be seen that, when the recess in *c* works round opposite the hour, the wire *d* drops down in the recess, bringing with it *e*, which falls on the two ends of the wire from the battery brought in at the sides of the clock. The strip *e* cannot be seen, being above the face. The disc could be fitted to any clock, being nothing more than a piece of sheet brass with a groove cut in it

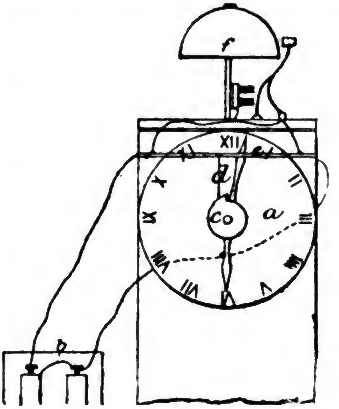

FIG. 50.

with a file, to prevent the wire from slipping out. There should be a switch, to turn the current off or stop it. The gong is shown fixed on the top of clock, and battery and clock on mantel-shelf. A common house-bell will do for a gong, supported on a piece of brass wire. The disc *c* is of course to be carried by the hour hand.

(3) Have a disc, about 2 in. diam., fastened on to the shaft of the hour-hand, so that it revolves once in 12 hours, and notched about ⅛ in. deep, to allow the pin of contact-rod to drop, and make contact at *a b*. Divide the disc into 12 equal parts for the hours, and half the spaces for the half-hours, and number them as shown in Fig. 51,

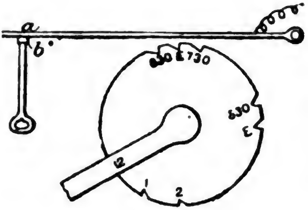

FIG. 51.

when fixed, the centre of the hour-hand should always be over the figure 12. Carry the wire from the battery to the contact-rod, as shown, and not through the joint. This will ring the bell all through the night; but you can switch it off and on, or, if this is unsuitable, make the disc revolve only once in 24 hours, and divide and notch to suit, so that more than one half of disc would be blank. The contact-rod you must shape to circumstances, and make the minute and hour hands coincide.

(4) In Fig. 52, *a* is a disc of thin sheet brass, with notch cut in it; through the centre is soldered a tin tube to slip tightly on the spindle of the wheel that carries the small hand of the clock, with 2 brass pins soldered on the outer face, just long enough to project through the face of the clock to turn the disc round with. *b* is a piece of brass wire about ⅛ in. thick, screwed at one end about 1 in. down, and with 3 nuts fitted; the other part is hammered flat, to form a spring, and filed down to the required stiffness, which of course must not be great. The end that presses on the edge of the disc has a small notch cut in to prevent slipping. *c* is another brass wire same thickness as *b*, with 3 nuts, and bent as in sketch. Take off the clock face and hands, bore 2 holes through the side of clock-case, one above the disc and the other below, as shown; then by means of 2 nuts fix each wire in position; the other nut serves to connect the wires from battery. All is hidden when the face is put on. A small piece of platinum is soldered on the spring *b*, where it drops on *c*, also a piece on the end of *c* to form more perfect connection. The action is thus: Suppose 6 o'clock is the time you require to rise in the morning: at 6 o'clock in the evening, turn the disc round by means of the pins until the spring drops into the notch and falls on *c*; the connection is then made. As the clock moves, the disc raises *b* until 6 o'clock A.M., when it drops, and sets the bell ringing. The clock may be in the kitchen, and the wires go through ceiling to bell hanging on wall in bedroom. A simple

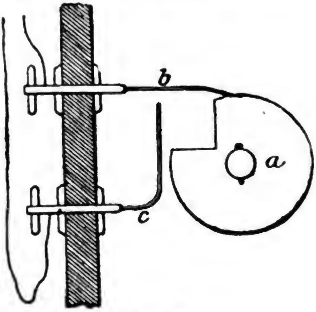

FIG. 52.

break is made thus: Solder a small plate with 2 screw-holes on 3 in. of ¼-in. brass tube and nail it to the wall in bedroom; then put a small piece of cork in the bottom of tube, cut one of the wires from battery, file one end to a point, and put it up a short way through the cork; to the other wire solder 8 in. of gilt picture cord with a brass wire 3 in. long soldered to the other end of picture cord, then pour a small quantity of mercury into the tube. When retiring for the night, merely wind up the clock, and put the brass wire at end of picture cord into the tube, which forms the connection. When the bell rings in the morning, take the wire out of tube, which breaks the connection. Gilt picture cord forms good flexible connections to the clock; solder about 8 in. to end of each wire.

(5) Put 2 pins in the minute-wheel, and let them lift a light spring; this will give a contact-maker every half-hour. Then a pin on the hour-wheel to suit each hour that a signal is wanted for. Count the teeth, and divide that number by 12, thus having so many teeth for each hour. Mark one tooth "12," and at equal distances others "1," "2," etc. Miss pins at hours not wanted, and where a half-hour signal is needed, insert a pin half-way between the hours. The arrangement is shown in Fig. 53: *a*, minute-wheel, with its 2 pins; *b*, hour-wheel, with its pins; *c*, light brass springs, to be lifted by the pins in the wheels; *d*, adjusting screws. The spring-studs must, of course, be insulated from the clock-plate.

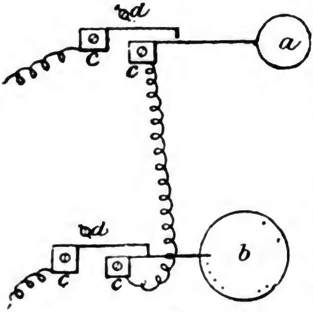

FIG. 53.

(6) Fig. 54.—*a* is the clock; *b*, battery; *c*, bell. The wire *d* from one terminal of the bell is connected with any part of the works behind the clock; the wire *e* leads from the battery to the other terminal of the bell; and the wire *f* is placed at whatever hour the bell is wanted to ring. *f* has a little crook at the end, so that, when the hour hand of the clock touches it, it is carried round with it, the bell continuing to ring till the crook detaches itself by the hand going round —i.e. about 3 hours. *f* is placed in such a manner that, although the hour hand touches it, the minute hand passes above it. This adjustment, though not so scientific as others, is equally successful.

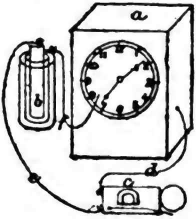

FIG. 54.

(7) *Clock Attachment to ring Bell at Certain Hours.*—Just prepare a thin disc of a non-conducting substance, such as vulcanite or hard wood, and mount this under the hour hand, or it can be put upon the axis of the wheel which carries the hour hand, just behind the dial. Let the disc have a metal centre to come in contact with the hour-hand axis. From the centre of this disc have wires run to the edge, these wires coming at points corresponding with the times the bell

is required to ring. A light spring is then provided attached to any convenient point, the clear end of the spring pressing on the edge of the disc. As the disc revolves so will the spring come in contact with the wires which come to the edge of the disc. By having one wire of an electric circuit connected to the spring, and one wire to the centre of the disc, a complete circuit will be made each time a disc wire comes under the spring. The bell will ring for a minute or two, or several minutes, according to how the spring or the ends of the disc wires are shaped to remain in contact with one another. It also follows that the finer the disc wires and the larger the disc the shorter the contact will be.

Tell-tale Clock.—A drum *d* (Fig. 55) carries a strip of paper wound upon it. The surface has grooves cut in it, either circular or (if to indicate for more than 12 hours without attention) spiral. In the latter case, one end of axis of drum is cut with a screw of the same pitch as the grooves on the drum, and works in a fixed nut, so that, when rotated, the drum travels along an axial line at such a rate that the grooves retain the same relative position to a fixed point, such as the indenting point, presently to be described. The drum has the hours engraved at one end, and is made to rotate once in 12 hours. A spring (not shown) holds the cylindrical armature *a* off the face of electro-magnet *m* until a current passes, when the lever *l* is drawn down, and the point *p* makes a puncture in the paper. The position of this puncture relatively to lines drawn from the figures on end of drum along the paper in direction of drum's length, will indicate the time at which current passes. A simple contact spring, such as is used for ringing electric bells, is pushed by the watchman when making his rounds, and a record is made on the paper.

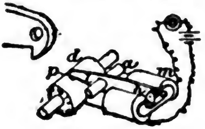

FIG. 55.

* * *

ELECTRIC MOTOR

FOR USE IN A SMALL WORKSHOP.

Electric Motors.—(*a*) It is generally understood that an efficient electric motor cannot be made without the use of machinery and fine tools. It is also believed that the expense of patterns, castings, and materials of various kinds required in the construction of a good electric motor is considerable. The little motor shown in Fig. 63 was devised and constructed with a view to assisting amateurs and beginners in electricity to make a motor which might be driven to advantage by a current derived from a battery, and which would have sufficient power to operate an ordinary foot lathe or any light machinery requiring not over 1 man power.

The only machine work required in its construction is the turning of the wooden supports for the armature ring. The materials cost less than 8*s*., and the labour is not great, although some of the operations, such as winding the armature and field magnet, require some time and considerable patience. On the whole, however, it is a very easy machine to make, and if carefully constructed will certainly give satisfaction. Only such materials as may be procured anywhere are required. No patterns or castings are needed.

Beginning with the armature, a wooden spool A (Fig. 56) should be made of sufficient size to receive the soft iron wire of which the core of the armature is formed. The wire, before winding, should be varnished with shellac and allowed to dry, and the surface of the spool on which the wire is wound should be covered with paper to prevent the sticking of the varnish when the wire is heated, as will presently be described. The size of the iron wire is No. 18 American wire gauge. The spool is $2\frac{3}{16}$ in. diameter in the smaller part and 2 in. long between the flanges. It is divided at the centre and fastened together by screws. Each part is tapered slightly to facilitate its removal from the wire ring. The wire is wound on the spool to a depth of $\frac{3}{8}$ in. It should be wound in even layers; and when the winding is complete, the spool and its contents should be placed in a hot oven, and allowed to remain until the shellac melts and the convolutions of wire are cemented together. After cooling, the iron wire ring B (Fig. 57) is withdrawn from the spool, and covered with a single thickness of adhesive tape, to ensure insulation.

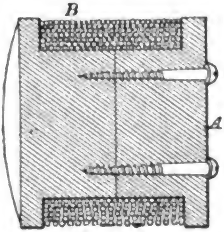

FIG. 56.

The ring is now spaced off into 12 equal divisions, and lines are drawn around the ring transversely, dividing it into 12 equal segments, as shown in Fig. 58. Two wedge-shaped pieces C of hard wood are notched and fitted to the ring, so as to enclose a space in which to wind the coil. This coil consists of No. 16 cotton-covered copper magnet wire, 4 layers deep, each layer having 8 convolutions. The end *a* and the beginning *b* of the winding terminate on the same side of the coil. The last layer of wire should be wound over 2 or 3 strands of shoe thread, which should be tied after the coil is complete, thus binding the wires together. When the first section of the winding is finished, the wire is cut off and the ends (about 2 in. long) are twisted together to cause the coil to retain its shape. After the completion of the first section, one of the pieces C is moved to a new position, and the second section is proceeded with, and so on until the 12 sections are wound. The coils of the ring are then varnished with thin shellac varnish, the varnish being allowed to soak into the interior of the coils. Finally the ring is allowed to remain in a warm place until the varnish is thoroughly dry and hard.

Care should be taken to wind all the coils in the same direction, and to have the same number of convolutions in each coil. A convenient way of carrying the wire through and around the ring is to wind upon a small ordinary spool enough wire for a single section, using the spool as a shuttle.

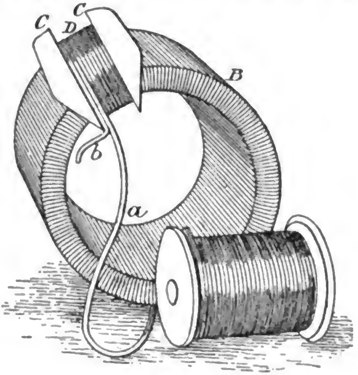

FIG. 57.

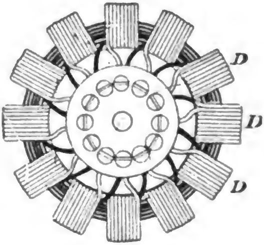

FIG. 58.

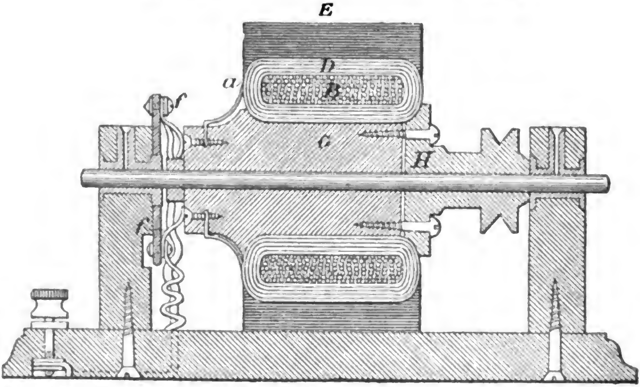

FIG. 59.

The ring is mounted upon a wood support or hub G (Fig. 59), and is held in place by the wooden collar H, both hub and collar being provided with a concave flange for receiving the inner edges of the ring. The collar H is fastened to the end of the hub G by ordinary brass wood screws. Both hub and collar are mounted on a $\frac{9}{32}$ in. steel shaft formed of Stubs' wire, which needs no turning. A pulley is formed integrally with the collar H. The end of the hub G, which is provided with a flange, is prolonged to form the commutator, and the terminals *a b* of the ring coils are arranged along the surface of the hub and inserted in radial holes drilled in the hub in pairs. The wires are arranged so that one hole of each pair receives the outer end of one coil, and the other hole receives the inner end of the next coil, the extremities of the wire being scraped before insertion in the holes. The distance between the holes of each pair is sufficient to allow a brass wood screw to enter the end of the hub G, and form an electrical contact with both wires of the pair, as shown in Fig. 58.

There being 12 armature sections and 12 pairs of terminals, there will of course be required a corresponding number of brass screws. These screws are inserted in the end of the hub G, so as to come exactly even with the end of the hub. This completes the armature and the commutator.

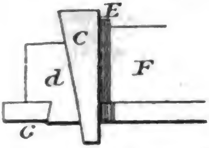

FIG. 60.

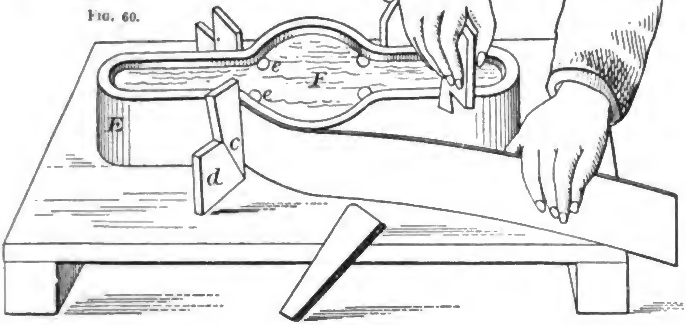

FIG. 61.

Before proceeding to mount the armature shaft in the journal boxes, it will be necessary to construct the field magnet, as the machine must, to some extent at least, be made by "rule of thumb."

The body E (Fig. 61) of the field magnet consists of strips of Russia iron, such as is used in the manufacture of stoves and stove pipe. The strips are 2½ in. wide their combined length being sufficient to build up a magnet core $\frac{7}{16}$

in. thick, of the form shown. The motor illustrated has 15 layers of iron in the magnet, each requiring about 26 in. of iron, approximately 33 ft. altogether.

The wooden block F, on which the magnet is formed, is secured to a base board G, as shown in Fig. 60, and grooves are made in the edges of the block, and corresponding holes are formed in the base to receive wires for temporarily binding the iron strips together. Opposite each angle of the block F, mortises are made in the base board G, to receive the keys *d* and wedges *c*. Each key *d* is retained in the mortises by a dovetail, as shown in Fig. 60. By this arrangement, each layer of the strip of iron may be held in position as the formation of the magnet proceeds, the several keys *d* and wedges *c* being removed and replaced in succession as the iron strip is carried around the block F. When the magnet has reached the required thickness, the wedges *c* are forced down so as to hold the iron firmly, then the layers of iron are closely bound together by iron binding wire wound around the magnet through the grooves *e* (Fig. 61) and holes in the base board G.

The next step in the construction of the machine is the winding of the field magnet. To ensure the insulation of the magnet wire from the iron core of the magnet, the latter is covered upon the parts to be wound by adhesive tape or by cotton cloth attached by means of shellac varnish.

The direction of winding is clearly shown in Fig. 62. 5 layers of No. 16 magnet wire are wound upon each section of the magnet, the winding of sections 1 and 2 being oppositely arranged with respect to each other. In like manner, the winding of sections 3 and 4 is oppositely arranged. The winding of section 1 is also opposite to that of 3, and that of 2 is opposite to that of 4. The winding begins at the outer end of the magnet, and ends at the inner end of the section. When the winding is completed, the temporary binding is removed. The outer ends of 1 and 2 are connected together, and the outer ends of 3 and 4 are connected. The inner ends of 2 and 4 are connected. The inner end of 3 is to be connected with the commutator brush *f*. The inner end of 1 is to be connected with the binding post *g*, and the binding post *g* is to be connected with the commutator brush *f*.

The field magnet is now placed upon a base having blocks of suitable height to support it in a horizontal position. A block is placed between the coils to prevent the top of the magnet from

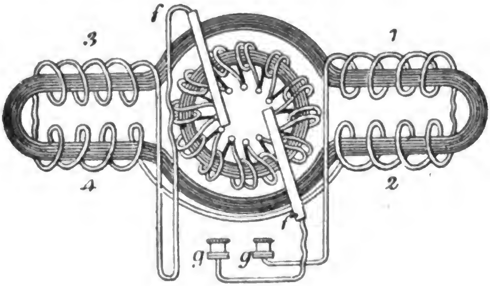

FIG. 62.

drawing down upon the armature, and the magnet is secured in place by brass straps, as shown in Fig. 63.

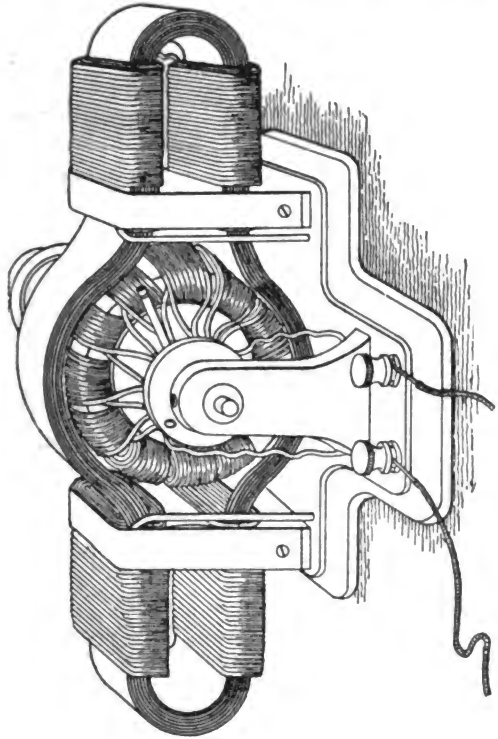

Fig. 63

The armature is wrapped with 3 or 4 thicknesses of heavy paper and inserted in the wider part of the field magnet, the paper serving to centre the armature in the magnet. The armature shaft is levelled, and arranged at right angles with the field magnet. The posts in which the armature shaft is journaled are bored transversely larger than the shaft, and a hole is bored from the top downward, so as to communicate with the transverse hole. To prevent the binding of the journal boxes, the exposed ends of the armature shaft are covered with a thin wash of pure clay and allowed to dry. The posts are secured to the base, with the ends of the armature shaft received in the transverse holes. Washers of pasteboard are placed upon the shaft on the opposite sides of the posts, to confine the melted metal, which is to form the journal boxes. Babbitt metal, or in its absence, type metal, is melted and poured into the space around the shaft through the vertical hole in the post. The journal boxes thus formed are each provided with an oil hole, extending from the top of the post downward. If, after cleaning and oiling the boxes, the shaft does not turn freely, the boxes should be reamed or scraped until the desired freedom is secured.

All that is now required to complete the motor is the commutator brushes *f f*. They each consist of 3 or 4 strips of thin hard rolled copper, curved as shown in Fig. 59, to cause them to bear upon the screws in the end of the hub G. The brushes are secured by small bolts to a disc of vulcanised fibre, or vulcanite, at diametrically opposite points, as shown in Fig. 64, and the brushes are arranged in the direction of the rotation of the armature. In the brush-carrying disc is formed a curved slot for receiving a screw, shown in Fig. 64, which passes through the slot into the post and serves to bind the disc in any position. The disc is mounted on a boss projecting from the inner side of the post concentric with the armature shaft. The brushes are connected up by means of flexible cord as shown in Figs. 59 and 62. The most favourable position for the brushes may soon be found after applying the current to the motor. The ends of both brushes will lie approximately in the same horizontal plane. When the motor is in operation, the direction of the current of the conductor of the field magnet is such as to produce consequent poles above and below the armature.

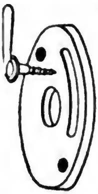
FIG. 64.

Eight cells of plunging bichromate battery, each having one zinc plate 5 × 7 in. and 2 carbon plates of the same size, will develop sufficient power in the motor to run an ordinary foot lathe or 2 or 3 sewing machines.

The dimensions of the parts of the motor are tabulated below :—

Length of field magnet (inside) .	10¼ in.
Internal diameter of polar section of magnet	3¾ ,,
Width of magnet core	2¼ ,,
No. of layers of wire to each coil of magnet	5
No. of convolutions in each layer	34
Length of wire in each coil (approximate)	95 ft
Size of wire, Am. W. G. . . .	No. 16.
Outside diameter of armature .	3¼ in.
Inside diameter of armature core	2 3/16 ,,
Thickness ,, ,, ,,	⅜ ,,
Width ,, ,, ,,	2 ,,
,, ,, ,, wound	2¼ ,,
No. of coils on armature . . .	12 ,,
No. of layers in each coil . . .	4
No. of convolutions in each layer	8
Length of wire in each armature coil (approximate)	30 ft.
Size of wire on armature, Am. W. G.	No. 16.
Length of armature shaft . . .	7¼ in.
Diameter of armature shaft . .	9/32 ,,
,, ,, wooden hub . . .	1¼ ,,
Distance between standards . .	5¼ ,,
Total weight of wire in armature and field magnet	6 lb.

(G. M. Hopkins.)

* * *

ELECTRIC WIRING

TABLE: SIZES OF WIRES AND CABLES (CONDUCTORS) FOR A GIVEN NUMBER OF INCANDESCENT LAMPS.

Conductor, Standard Gauge.	Will carry, Ampères.	No. of 100-volt. 16 c.p Lamps (or double this number of 8 c.p. lamps).	No. of 50-volt 16 c.p. Lamps (or double this number of 8 c.p. lamps).
$\frac{1}{18}$ or $\frac{3}{22}$	1·8	2	1
$\frac{1}{16}$ or $\frac{3}{20}$	3·2	4	2
$\frac{1}{15}$ or $\frac{7}{22}$	4·2	6	3
$\frac{1}{14}$ or $\frac{3}{18}$	5·0	8	4
$\frac{7}{20}$	7·2	12	6
$\frac{7}{18}$	12·8	20	10
$\frac{7}{16}$	22·7	36	18
$\frac{7}{15}$	29·0	50	25
$\frac{19}{17}$	48·0	75	38
$\frac{19}{16}$	62·0	95	48
$\frac{19}{14}$	96·0	155	78

With 100 volt E.M.F. the circuits can be about 80 yd., or half this distance with 50 volt pressure. If a greater distance occurs the resistance is increased proportionately, and a larger conductor becomes necessary, as there should not occur a greater fall of potential than 2 volts. The increase in the area of the conductor can be proportionate, so that if for twelve 16 candle-power lamps on an 80 yd. circuit a $\frac{7}{20}$ * conductor is needed, then a 160 yd. circuit will require a $\frac{14}{20}$ conductor, or its equivalent. Always remember that a circuit can be spoiled by using a conductor one size too small.

Circuits and their Arrangement.—In works of a moderate size the system of wiring commonly adopted is to run a pair of mains from bottom to top of building, and to take flow and return branches from these to the lamps as Fig. 65. After passing a certain amount of work the mains may be reduced in size proportionately to the amount of work before them. There is no occasion to do this unless the saving in cable is considerable. The lamp branches are of smaller conductors than the mains.

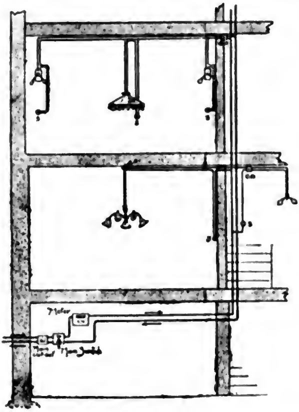

FIG. 65.

In this example it will be seen that there is a main switch on the street side of the meter, and a main cut-out accompanies it as shown, both these being necessary in every case. It is not usual to put another switch in the mains on the consumer's side of the meter unless a slightly different system having a distributing board, is adopted. Switches can, however, be put where-ever desired. All lamp branches have cut-outs, and the point at which the mains are reduced in size, as just referred to, should be provided with a cut-out also. Switches are put to the lamps as a matter of course, but where it is desired to operate several lamps by one switch, it is simply arranged as will be illustrated directly.

Where a distributing board is used the arrangement of connections is similar to Fig. 66. In the case illustrated, the board is really a device for splitting up the mains into three (or more) pairs of smaller branches, each conveniently fitted with a switch and cut-out compactly placed on the one board. This method is usually adopted in all important works, as it gives a more convenient and complete control over the installation when it is a large one. The cut-outs to the branches are on the board (slate base) as stated, but if any of the branches are practically vertical branch mains with lamp circuits of smaller conductors branched from them, then each of the latter should have a cut-out.

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* $\frac{7}{20}$ means a strand wire or cable of seven 20-gauge wires.

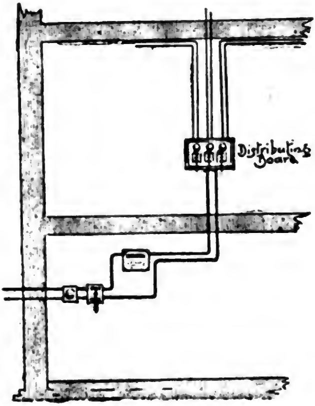


Fig. 66.

The methods of wiring the lamp circuits when a number are on one circuit, operated by a single switch, are several. Fig. 67 is known as the parallel system, and it will be seen that the chief circuit, probably a branch main, has lamps connected by branch lamp circuits. By this plan either lamp can have an independent switch if desired. Occasionally this system has two or more lamps on a branch, the current passing through one lamp before acting on the second one. This is not a commendable plan if it can be avoided, as, with two lamps as Fig. 68, the E.M.F. requires to be double that needed for a single lamp. This, however, admits of smaller wires being used. On account of the high E.M.F. required, the series system as Fig. 68 is not recommended, although it is often adopted with arc lamps which do not require so high a pressure. It might be thought that the series system was well suited for lighting round the walls of large rooms, but it is decidedly preferable to use the parallel system. The latter can be arranged as Fig. 70, to equalise the fall of potential as it is called, so that the first and the last lamp will be about

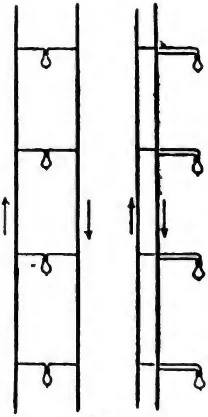


Fig. 67.

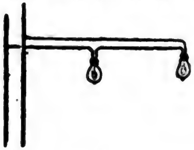


Fig. 68.

equally bright, which it might not be with Fig. 69, if the circuit was a long one.

Another method of equalising the current to a number of lamps is as Fig. 71, and generally known as the ring system. The term ring would make it appear that the conductors were run in a circle, but this is not necessary. If this method is adopted for a series of lights along the cornice of a ceiling, then it would be an oblong or square circuit as illustrated.

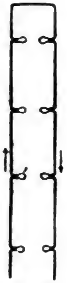


FIG. 69.

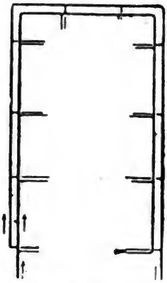


FIG. 70.

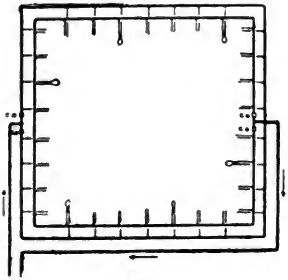


FIG. 71.

Arc lamps can be connected out of the wiring used for an installation of incandescent lamps. A branch flow and return is taken as usual, but before the current reaches the lamp it has to pass through a "resistance" (which usually has the switch connected with it) as Fig. 72.

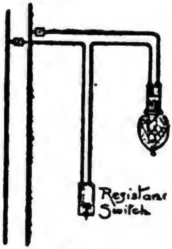


FIG. 72.

Joints.—A badly made joint is the same as an imperfection in the wire or cable, as it does not admit of a free and full flow of the current. The result is an insufficient current for the lights, and very probably the heating up of the spot. It is one of the most likely causes of fire. A badly made joint usually means imperfect contact between the two ends of the conductors, and, referring to the water pipe analogy again, it is like putting a piece of ½-in. tube in a 1-in. service and expecting the full volume to flow that an unrestricted 1-in. pipe is capable of affording. It will be found that fire office rules have something to say about joints, and most of them specify resin as the flux for soldering. There is no objection to this with plain wires or cables of a few strands, but with cables of say 30 strands skill will be needed to make the flux flow properly and cleanly through this mass of wire, for it is imperative that the solder pass right through and make a perfectly solid mass of the strands. Surface soldering is useless, and brings all the dangers there are into existence. In America the use of spirits is permitted, and there is much to be said in favour of this. Spirits have a cleansing effect, and, most important, a moderately unskilled man has every chance of making a sound, if not a handsome, joint. Of course, the fault of spirits is that, if not properly killed, or if carelessly used, there may be a corrosive action set up.

Single wires have the ends twisted together and soldered. Single branch wires are twisted on as Fig. 73, and soldered. Small cables may have the wires at the ends opened, forced together and then interwound, spliced in fact, and afterwards soldered. Another method with small cables is to solder the ends solid, and clean them off to butt together; a clip or short piece of tinned brass tube then receives the two ends and the whole is sweated solid. With the larger cables it is the rule to make a scarfed joint as Fig. 74.

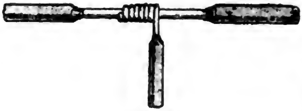


FIG. 73.

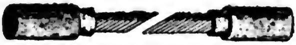
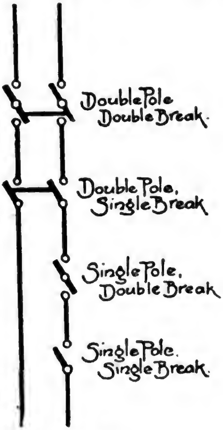


FIG. 74.

To effect this the wires or strands are opened out, cleaned, and then tightened up again with pliers. The ends are then soldered solid and afterwards bevelled off as shown. The ends are held soundly together, and tightly bound with No. 20 wire, the whole being afterwards soldered solid. A branch or tee joint on a cable is made in a similar manner to Fig. 74, except that the branch cable has its strands opened out, one half being wound round each way and soldered.

Switches and Cut-outs.—The switches used for single lamps, or sets of lamps, in a room, need no describing. The variety is very great, and the majority now made can be relied upon. Every reliance can be placed in those made by well-known firms. The main and large branch switches need description, as they fulfil a very important purpose in every installation. The main switch is that which the supply company have on the main side of the meter, so that connection between the mains and the house can be cut off, the same as with a gas supply. These switches are made either "single pole" or "double pole," the former operating on one wire only, while the latter opens or closes both positive and negative wires at once. Both these are made either single or double break, meaning that when open or "off" the main is broken in one or two places. Fig. 75 will diagrammatically explain how the four different kinds of switches work. The single-pole single-break switch is seldom used for mains, and in many, if not the majority, of cases, the double-pole double break is specified and adopted. Main switches are mounted on slate bases (which should be polished or treated so as to withstand moisture),*


Double Pole Double Break.
Double Pole, Single Break
Single Pole, Double Break
Single Pole. Single Break.
FIG. 75.

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* A film of water is a most successful conductor of electricity.

as there is a possible risk of arcing, which would set fire to an inflammable base. The requisite features in a main switch are: (1) china or slate base; (2) a quick break to reduce sparking; (3) a throw-off action so that the switch cannot be left partially or insufficiently open, and arcing takes place; (4) ample contact surface, preferably a rubbing contact, that will adjust itself to wear and tear; (5) solidity of construction; (6) good terminals, well attached, for the cables to be connected to. These are provided either by clamp screws or by sockets into which the cables are soldered.

Of "cut-outs" there are various kinds of small and ornamental designs for rooms, also embodied in the ceiling roses of pendent lights; and of a larger kind for mains or main switch-boards. The principle of a cut-out, or safety fuse, is to cause the current to pass through a piece of strip of metal which will in no way interfere with its free passage up to certain limits (its normal strength), but which will melt if the E.M.F. rises sufficiently to cause heat in the conducting wires. The metallic strip or wire which melts is usually tin, or sometimes an alloy of tin and lead. Main cut-outs, also the larger branch fuses, are either single or double pole, but preferably the latter, as a single pole will not afford safety under every possible condition. The situations of cut-outs should have consideration, for they do come into operation occasionally, and then it is necessary to put new tin strips or wires in. Bases and covers of cut-outs should be of porcelain.

Electric Light. — *Wiring in Metallic Conduits.*—At the present time the practice of using steel conduits or tubes for the covering of wires of electric lighting systems has become almost universal, and promises to be quite so at a very early date. Everyone executing electrical work of this kind realises the many advantages the conduits offer, so much so that few installations of any importance are now completed except on this system. During the comparatively few years since the system was introduced by The Simplex Steel Conduit Co. Ltd., probably no other branch of electrical industry has shown such a marked development and obtains such general approval. It would be beyond the scope of this work to fully describe the system, which is capable of application to the most difficult cases, especially where there is a liability to the presence of inflammable gases; as the Simplex Company issue an admirable booklet giving details of the methods of installation. Readers who wish for more general information on modern methods of wiring should refer to the work by Ibbetson, recently published by E. and F. N. Spon, Ltd.

* * *

ELECTRO-PLATING AND ELECTRO-DEPOSITION.

(*See also* ELECTRIC BATTERIES, ELECTROTYPING, GALVANISING, GILDING, SILVERING, TINNING, ETC.)

THE first and most important operation in all branches of the deposition of one metal upon another, is to effect a thorough and chemical cleansing of the surface of the metal upon which the coating is to be deposited.

Cleansing Copper and its Alloys, Brass, etc.—This is done in six operations. (1) Cleansing by fire or by alkalies. (2) Dipping. (3) Dipping in old aquafortis. (4) Dipping in new aquafortis and soot. (5) Dipping in compound acids for a bright or dead lustre. (6) Dipping in nitrate or cyanide of mercury.

By Fire or by Alkalies.—This is to remove any foreign substances, especially those of a fatty nature, which are destroyed by heating the pieces in every direction over a gentle fire of charcoal, breeze, or spent tan. A muffle furnace, heated up to a dull red heat, is preferred; but small articles may be cleansed in a hot revolving cylinder. This operation is not adapted to very delicate articles, or for table-forks and spoons, which must keep their toughness, or to those pieces in which the different parts are united by soft solders. Boil such articles in a solution of potash or soda, which renders the fatty substances soluble in water. This is done in a cast-iron kettle, provided with a cover, containing a boiling concentrated solution of carbonate of potash or soda, or of caustic alkali. The caustic potash or soda must be dissolved in ten times its weight of water. This solution lasts a long time; when it has lost part of its power, it may be revived by a few fragments of caustic alkali. At the boiling point it will cleanse copper in a few seconds. If the articles to be scoured are joined with tin solder, they must not be allowed to remain too long in the caustic liquor, which would dissolve the solder and blacken the copper.

Dipping. — The pieces are then dipped in a mixture of 5–20 parts in weight of sulphuric acid at 66° B. for 100 parts of water. Most of the pieces to be cleansed may be dipped hot in this mixture; but certain alloys, in which tin, zinc, or antimony predominates, such as cast bronze, must not be so treated, as the sudden cooling will occasion cracks and flaws. Copper articles may remain any length of time in the dipping-bath; they should not be removed before the black coat of copper binoxide, caused by the heating is entirely dissolved. The remaining coat of red copper protoxide is unacted upon by the sulphuric acid. Articles having parts made of iron or zinc must not be submitted to the action of dilute sulphuric acid, or they will be entirely dissolved; therefore avoid the use of implements or wires of iron, zinc, or steel. A dipping-bath which contains copper in solution from previous operations will not suit for articles which may contain iron, tin, solder, antimony, bismuth, or lead. In such a case, use a newly made dipping-bath and a small proportion of acid. Articles which have been cleansed by alkalies must be washed before being put into the dipping-bath, or pickle. Thorough and rapid rinsing in fresh water, before and after each of the following operations, must be strictly attended to. The various manipulations which complete the cleansing succeed each other without interruption; and the articles must be stirred as well as possible in the acid baths and in the rinsing water. After dipping and rinsing, the various pieces are fixed to a brass wire, or hooked upon brass or copper hooks. Small articles of jewellery are suspended to a stout copper wire. These hooks are better if made of pure copper than of brass, and it is still better to use glass hooks, which are cheap and are not corroded by the acids. Such hooks or supports can be made by bending glass rods, by the heat of a charcoal fire, or of a gas burner, to the desired shape. Those objects which cannot be suspended or attached to hooks, are put into perforated ladles of porcelain or stoneware. It is less economical, but sometimes absolutely necessary, to use baskets of brass or copper wire cloth. Those who frequently have to cleanse very small articles will find it advantageous to employ a basket of platinum wire cloth, which, although expensive in the first cost, will be found cheaper in the end, as it is almost indestructible.

Dipping in old Aquafortis.—If you have any aquafortis (nitric acid) already weakened by preceding dippings, plunge into it the articles which have passed through the sulphuric acid pickle bath, and have been rinsed. They may remain there until the red coat of copper protoxide has entirely disappeared, leaving, after rinsing, a uniform metallic lustre. The dipping in old aquafortis, though not absolutely necessary, is recommended for two reasons: it economises the cost of fresh acids; and, as its action is slow, it prevents the too rapid corrosion of the cleansed copper during the time of the solution of the protoxide.

Dipping in Aquafortis and Soot.—After rinsing in fresh water, the articles are well shaken and drained, and then plunged into a bath composed of 100 parts nitric acid at 36° B., 1 common salt, 1 calcined soot. This mixture attacks the metal with the greatest energy, and the pieces should therefore not remain in it more than a few seconds. The volume of acid should be about 30 times that of the articles to be cleaned, in order to prevent too great an elevation of temperature due to the chemical reaction, which would result in the rapid weakening of the acid. After this bath—and rapid rinsing in order to prevent the production of nitrous vapours—the pieces present a fine red lustre, gold-yellow, or greenish-yellow, according to the alloy employed, and such as to make one believe that they are entirely cleansed of foreign matter; yet if the pieces in this state are plunged into a gilding or silvering bath, they become entirely black, and without any metallic lustre. If the pieces are put aside without rinsing, there rises on their surface a green froth and nitrous vapour, which indicate the decomposition of the acid with which they are contaminated. When the vapours have disappeared, the pieces, even after washing, remain of a dull black, on account of the formation of a basic copper salt which is not soluble in water. This last mode of operating, called blacking by aquafortis, is preferred by a few gilders, varnishers, and colour fixers, who find it economical to allow the production of nitrous vapours while the pieces are draining on top of the vessel which contains the acids. Any subsequent operation is to be prefaced by a rinsing in fresh water. When small objects, such as pins, caps, or eyelets, are to be dipped, they are put into a stoneware pot, with a small quantity of aquafortis, and then rapidly shaken and stirred. In this case the acid is entirely used up with the production of abundant vapours, and the objects remain blackened, and ready for a further cleansing. Care must be taken in the choice of aquafortis. Three kinds of nitric acid at 36° B. are to be found in the trade. One is perfectly white, another is straw-yellow, and another is more or less dark-red. The white acid, without nitrous gas, does not cleanse well, especially when freshly used. The red acid acts too powerfully, and pits the copper. The straw-yellow acid is preferred to the others. Nitric acid at 40° B. is too energetic and costly; however, certain operators who have to cleanse large quantities of copper wares prefer it on account of the rapidity of the operation. The acid is spent when its action on copper goods becomes too slow, and when the objects removed from the bath are covered with a kind of bluish-white film. Such acid is preserved for the preceding operation, namely, dipping in old aquafortis; or for dipping in the whitening bath. Very good aquafortis may cleanse imperfectly when the temperature is too low or too high. This accounts for the difficulty of cleansing in frosty weather, or during the great heat of summer.

Aquafortis for Bright Lustre.—There is an excellent way of obtaining a bright lustre on surfaces which have been dulled or slightly pitted by defective cleansing, or by passage through acids for removing gold or silver. Place them for a few minutes in a bath composed of 1 part old aquafortis, nearly spent, 6 hydrochloric acid, 2 water. The pieces, when removed from the bath, are entirely black, and must be thoroughly rinsed in water to remove the kind of black mud which covers them. They are then cleansed and dipped again. This bath will be found useful by electro-gilders. It is also convenient for removing the sand adhering to the castings of copper alloys. Large pieces may remain in the bath for 20–30 minutes, as this mixture acts very slowly on copper and its alloys,

Dipping in Compound Acids for a Bright Lustre.—These acids are of two kinds, according to the object in view. If the pieces are to have a bright lustre, they are stirred for 1 or 2 seconds in a liquid, prepared the day before, and cold, made of 100 parts nitric acid at 36° B., 100 sulphuric acid at 66° B., 1 common salt. In preparing this bath, nitric acid is first put into the vessel, and then sulphuric acid, which is much denser, and would not mix readily if it were put in first. At the time of mixing, especially when the salt is added, considerable heat and a quantity of acid and injurious fumes are produced, so that it is prudent to operate in the open air, or under a good chimney-hood with a moveable glass sash. As these acids must be employed cold, it is necessary to prepare them in advance. Copper articles, after this dipping, are lighter coloured and much brighter than after the passage through aquafortis. They may then be considered as completely cleansed, and must be immediately rinsed in plenty of clean water. The above acids are too energetic for small articles, such as pins or hooks, which are generally cleansed in stoneware colanders. As the small articles stop up the perforations, the acid cannot run out so quickly as desired, and begins to heat and give off fumes, the pieces blackening before they can be rinsed. Therefore, for small pieces, add to the above mixture one-eighth of its volume of water. Place the articles in a stoneware pot; stir rapidly with a small quantity of bitters, as the last mixture is termed, and then the whole is plunged into a quantity of fresh water as soon as the acid has sufficiently acted. This method is not economical, as the acid is lost; but the dipping liquors do not become heated.

Whitening bath consists of old aquafortis, sulphuric acid, common salt, and uncalcined soot. Pour into a large stoneware vessel a certain quantity of old aquafortis from previous dippings, and then add twice the volume of sulphuric acid at 66° B. The mixture is allowed to cool off until the next day. The copper nitrate of the old aquafortis becomes converted into sulphate, which, by cooling, crystallises against the sides of the vessel. Decant the liquid portion into another vessel, and then add 2–3 per cent. of common salt, and as much of calcined soot. This mixture is much less energetic than the compound acids for a bright lustre, and often replaces them advantageously. The crystallised copper sulphate is collected and sold. This bath is strengthened, when necessary, by the addition of stronger aquafortis and oil of vitriol. To replace the portion used up during the day, equal quantities of old aquafortis and oil of vitriol are added at the end of the day. The next morning the liquors are decanted, and the copper sulphate is gathered. Soot and common salt in sufficient proportions are then added. In this manner a perpetual and cheap whitening bath is prepared.

Compound Acids for a Dead Lustre. If it is desired to give the objects a dead lustre, they are, after dipping in aquafortis and rinsing, plunged into a bath, prepared previously, composed of 200 parts nitric acid at 36° B., 100 sulphuric acid at 66° B., 1 common salt, 1–5 zinc sulphate. Copper articles may remain 5–20 minutes in the cold bath, and the dead lustre will be the more apparent the longer the immersion has been. From this bath, after a long rinsing, the objects have an earthy appearance. This dulness is removed by a rapid passage of the pieces through the compound acids for a bright lustre, and by an immediate rinsing. If they remain too long in the latter acids, the dead lustre will disappear, and the operation for dead lustre will have to be repeated. If a bath for the bright lustre is not at hand, the objects, after rinsing, may be rapidly passed through the dead-lustre bath, which will remove the dulness of the lustre caused by too long immersion. After long use, the compound acids for a bright lustre may be employed in a certain measure for a dead-lustre bath. The mode of operation remains the same.

Dipping in Nitrate of Mercury.—This operation consists in plunging the cleansed articles for 1–2 seconds into a solution of 2⅕ gal. water, ⅓ oz. nitrate of mercury, ⅔ oz. nitric or sulphuric acid. When nitrate of mercury is poured into the water, a thick cloud is formed, of a yellowish-white colour, which subsequently disappears. Stir the mixture before using it. The proportion of mercury salt abovenamed must be modified, according to the size of the pieces, and the nature of the alloy. Thus less mercury will be used for light pieces of jewellery which need a very thin deposit. On the other hand, more mercury is required for heavy objects, such as table ornaments, which should receive a thick deposit of gold or silver. The latter must come from the mercurial solution with a perfectly white and bright appearance, looking like silver, whilst the colour of the light articles is scarcely changed. After a perfect cleansing, the pieces will, after passing through a strong mercurial solution, be perfectly white and bright. But there will be a cloudy appearance, or various shades of colour, if the cleansing has not been properly done. The amalgamating bath becomes spent by use ; it may be revived by the addition of a few drops of mercury nitrate ; but it is better to prepare a fresh one. No intervals must be allowed between the various operations of cleansing. The dipping baths are ordinarily held in vessels of glass, stoneware, porcelain, or of any other material which resists the corrosion of acids. Common earthenware and that with a lead glaze must be carefully avoided. The dipping pots must be rather high, and be furnished with a cover, in order to prevent evaporation. Those with ground edges may be covered with a pane of glass. Wide open-mouthed earthen pans are very good for rinsing. A large hood, communicating with a chimney, and closed with a sliding glass sash, chould contain the following apparatus for complete cleansing operations : A furnace and separate pans for first dipping, old aquafortis, aquafortis and soot, compound acids for dead lustre, compound acids for bright lustre, solution of mercury nitrate, acids to dissolve gold from old pieces ; acids to dissolve silver from old pieces ; with two large pans for rinsing with a constant flow of water. If the draught of the chimney is not sufficient, a small fire may be kindled under the hood. A gas-burner is often sufficient. The pot of mercury nitrate, with two rinsing pans, may be placed near the plating bath.

Cleansing Iron.—Cast iron is cleansed by being immersed for 2–3 hours in water containing 1 per cent. sulphuric acid ; the metal is afterwards rinsed in cold water, and scoured with sharp sand and a fibre brush, or a coarse rag; then put again in the acid pickle, rinsed, and plunged into the plating bath. If more than 1 per cent. of sulphuric acid is added to the water, the length of the immersion must be shortened, otherwise the cast iron will be deeply corroded, and the carbon of the metal, which is insoluble in the pickle, will with great difficulty be removed by the friction of the sand. Cast iron does not gild or silver well, by a direct deposit of the precious metals. Copper or brass deposits are better, although far from perfect; but if cast iron is tinned, the coat is adherent, and will afterwards receive copper, brass, gold, or silver, if desired. If it is desired to keep cast iron cleansed for some time before plating it, it is necessary to preserve it in a liquor rendered alkaline by caustic lime, potash, or soda, or their carbonates; but caustic lime-water is the cheapest and most easy method, and cast iron which has remained in it for a few hours will not rust after a long exposure to a damp atmosphere.

The cleansing of wrought iron is effected in the same manner as cast iron, but it will bear a stronger pickle and a longer immersion, i.e. ordinary wrought iron covered with a film of black magnetic scale or of red rust. Whitened, filed, or polished iron must be treated like steel.

Cleansing Lead and Tin.—Tin, lead, and the alloys of these metals are much more difficult to cleanse than zinc. A rapid scouring with potash lye and a rubbing with a hard substance are the only means of effecting this. The objects are sometimes plunged into diluted hydrochloric acid; but the first operation is nearly always necessary. Notwithstanding the greatest care, the direct deposit of the precious metals is difficult, and does not adhere well. The results are much better if a coat of pure copper or brass is interposed between the low metal and the gold or silver.

Cleaning Silver. — Mechanical agents will not, like acids, act simultaneously on every part of the object, and it is impossible to entirely prevent the action of air, steam, gases, and acid fumes. Heat the object to a dull red heat upon a slow fire. If the silver is pure, it becomes covered with a thin bluish film; but if, as is nearly always the case, the silver is alloyed with a variable proportion of copper, the latter becomes oxidised, and covers the piece with a greyish-black coating. While the piece is still hot, plunge it into a boiling pickle of water and sulphuric acid, which dissolves the oxide. If the heat has been sufficiently protracted for oxidising all the copper on the surface, the object, when removed from the pickle, is of a perfectly dead white. It is greyish if the heating has been too short, and the operation must be repeated as many times as are needed for a perfect lustre. Or the silver may be placed in sheet-iron boxes filled with a mixture of powdered borax, lime, and charcoal dust. The borax dissolves the copper oxide as soon as formed. If the objects to be cleaned are hollow, it is necessary, before heating, to make a small hole which will allow of the escape of the air expanded by the fire. Without this precaution, the piece will burst open. When the piece is put into the pickle, the acid liquor enters through the hole, and takes the place of the air between the shells, and is difficult to remove. In order to prevent the spotting of the piece by this liquor, it is dipped for a few minutes into a very dilute solution of ammonia or of soda crystals, which prevents the action of the acid upon the silver. Then place the article between layers of dry and warm fir sawdust, which will absorb the saline solution. Nitric, instead of sulphuric, acid, may be used for the pickle bath. In this case, the water must be distilled, and the acid free from chlorine or hydrochloric acid, otherwise the silverware will be covered with a bluish-white film of silver chloride. This method will not suit articles in which iron or zinc may be present. In such cases, employ alkalies, and polish afterwards with very fine sand or pumice, with the aid of a stiff and short brush, or with a scratch-brush alone. Perfectly cleansed silver may directly receive a metallic deposit which will have the same dead lustre as the object itself, but it is customary, before introducing the articles into the plating bath, to scratch-brush them.

Bright Lustre for Small Articles.—Very small articles, which cannot be scratch-brushed, receive a bright lustre by mutual friction. The operation is generally performed with the hands. The articles to be brightened are introduced, together with box-wood sawdust, bran, or sand, into a bag; the ends of the bag being gathered into the hands with the thumbs inward, the bag is shaken to and fro. As this operation becomes very fatiguing, mechanical means may be employed to effect the shaking.

Cleansing Steel. — Polished articles of steel or iron must be first cleansed in a boiling solution of caustic lye, and rubbed with pumice dust, which scratches the polish slightly, and thus produces a better hold for the metals afterwards to be deposited. They are then rapidly passed through a bath composed of 1 qt. water, 12 oz. hydrochloric acid, 4 oz. sulphuric acid, rinsed in cold water, and plunged into the plating solution. Carefully avoid substituting nitric acid for the hydrochloric or sulphuric acid, of the above acid bath. Iron and steel may be well gilt, without an intermediary coat, in hot gilding baths. Silvering directly upon steel or iron is always imperfect and without adherence; it is therefore customary to interpose a coat of copper or brass, which renders the further operation of silver plating easy.

Cleansing Zinc.—Zinc is cleansed by being passed through a boiling solution of caustic lye, without remaining too long in it, because it may be corroded, and even dissolved; after rinsing, it is plunged for a few minutes into water containing 10–20 per cent. sulphuric acid, then rinsed in plenty of warm water, and, when necessary, brushed with a stiff brush and pumice dust, or scratch-brushed. This last operation is especially useful when parts have been united with tin solder which becomes black and dull by the alkaline and acid baths. Another method is to dip the articles rapidly into a cold mixture of 100 parts sulphuric acid, 100 parts nitric acid, and 1 common salt, and quickly rinse in cold water perfectly free from copper salt, which will blacken the zinc. If, instead of quickly cleansing the zinc, it is allowed to remain a little longer in the mixture, it acquires a dead lustre which may be utilised for producing contrasts between the various parts of the same ornament. The dead lustre will become a bright one, if the object is quickly plunged in several times, and rinsed as often, in the same compound acids. It often happens that the lines of tin or lead solder are black after being dipped into the acid bath; it is then sufficient to scratch-brush before placing the object in the plating solution. Zinc may be slightly amalgamated with the solution of nitrate of mercury; this increases the adherence of the deposits. It is often necessary, from some defect in cleansing, or in plating, which impairs the adherence of the deposits, to do the work over again. In such a case, remove the copper entirely by plunging the object into aquafortis and soot, until it appears black. Another dipping into the compound acids will render it perfectly clean and white, and ready to receive a new deposit.

Scratch-brushing. — Scratch-brushing is to remove the dead lustre on an object by the frequently repeated friction of the points of many stiff and straight metallic wires, called a scratch-brush or wire-brush. Its shape varies with the articles to be operated upon. A hand scratch-brush is made of numerous wires, stiff and straight, taken from a bundle or coil of large diameter, so that the wires have little tendency to curve. For delicate objects, scratch-brushes are made of spun glass, the fibres of which are very thin and elastic. For making a good hand scratch-brush, choose a bundle or coil of brass wire of the proper thickness, and wrap a good string tightly round it for about two-thirds of the intended length of the instrument, usually about 8 in. Then, with a cold chisel, cut the bundle of wire close to the string at one end, and at 2 in. from the other end of the string wrapping. Dip the end closed by the string into a neutral solution of zinc chloride, and plunge into melted tin, which solders all the wires, and prevents their separation, and injury to the hand of the operator. The tool is then fixed to a thin wooden handle which projects above the soldered end. Very small scratch-brushes are necessary for reaching small holes and corners. An old scratch-brush, the wires of which have been bent in every direction, and fixed to a long handle, is useful for rubbing the insides of certain pieces, such as vases. Scratch-brushing is seldom done dry ; the tool and pieces must be constantly wetted with a stream of water, which carries away the impurities. Good metallic deposits are only polished by the friction of the scratch-brush ; bad ones scale off from the defective adhesion. A large tub, with a board placed across it, on which to rest the pieces, may be used ; and various solutions are employed to assist the brushing, such as water and vinegar, or sour wine, or solutions of cream of tartar or alum, when it is desired to brighten a gold deposit which is too dark ; but generally a decoction of liquorice-root, horse-chestnut, or marsh mallow, all of which allow of a gentle rubbing with the scratch-brush, with the production of an abundant scum. Every 5 or 6 days the old liquid is carefully decanted, so as not to carry away the deposits at the bottom, as they always contain some of the precious metals, which are collected to be afterwards treated. For small objects and articles of jewellery, hold the scratch-brush as a writing pen, and the motion is imparted by the wrist only, the forearm resting on the edge of the tub. For larger articles of bronze, hold the fingers extended close to the fore part of the scratch-brush, so as to maintain the wires, and, with raised elbow, strike the piece repeatedly with a sliding motion at the same time. When a hollow is met which cannot be rubbed lengthways, a twisting motion is given to the tool. Circular wire-brushes, fixed on the spindle of a lathe, and the wires of which move all in the same direction, have been constructed for certain pieces of silversmith work, such as forks and spoons.

The brass wire used for the manufacture of hand or circular scratch-brushes is of various strengths. Thick wires are employed for bronzes, and thinner wires for lighter articles. The wires must be preserved stiff and straight. When a hand scratch-brush becomes too short, cut the twisted ends with a cold chisel, and a new portion of wire is uncovered by removing part of the string wrapping. To remove the twisted wire ends, rest the scratch-brush upon a lead block, and cut them with a sharp cold chisel, with one stroke of a hammer if possible. When they begin to curl, they are now and then beaten with a mallet of box-wood, upon a small block kept between the knees, so as not to produce a dead stroke. Scratch-brushes if kept too long in water become hard ; when greasy, they are cleansed in caustic potash ; oxide is removed by the compound acids. This last operation, and even dipping in aquafortis, is sometimes resorted to for diminishing the size of the wires, and making them smoother. The circular brush is occasionally resorted to for diminishing the size of the wires, and making them smoother. The circular brush is occasionally reversed, in order to change the direction of the wires.

Fig. 76 , *a b c d e f*, illustrates various forms of scratch-brush in common use. The circular pattern *c*, *d*, is, of course, employed in a lathe.

Lathe for Scratch-Brush.—An ordinary lathe is used for scratch-brushing, upon the spindle of which is fixed a circular brush of brass wires. A wooden frame covers the wire brush; it is open in front; the top supports a small reservoir from which a slender jet of water runs upon the brush. A board receives the projected water, and lets it fall into a zinc pan resting on the bottom of the box.

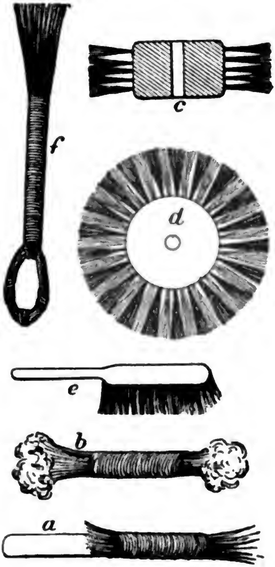

FIG. 76.

Batteries.—Although the dynamo has superseded the primary batteries in large plating works, very good work can be done with one of the many types described in the article, ELECTRIC BATTERIES, which see.

Vats, etc. — For small work, earthenware pans, white glazed inside, make very good vats. The size depends to a great extent on the class of work likely to be undertaken, but one holding 4–5 gal. is a very useful size. If possible, the pan should be about the same in depth as it is in diameter. A large bell-glass or fish globe serves well.

Three pieces of ⅜-in. brass or copper rod should be procured, long enough to reach across the vat. These are termed slinging rods, from which the anodes and articles to be plated are hung. Suitable suspending rods for the articles are made of small bent glass tubing.

The water used must be quite pure, in other words distilled water alone is suitable.

Amalgamating Salt.—This is a mercury salt with three acids, and is composed of the sulphate, nitrate, and bichloride of this metal. It is liquid, more or less coloured, very dense, and gives in water a yellow precipitate, which is dissolved by an excess of acid. It produces a violet stain on the skin, and amalgamates copper and its alloys thoroughly and rapidly. It is used for amalgamating the zincs of batteries, and dispenses with the metallic mercury; it is more easily applied, and prevents much trouble in gilding works. It is prepared by boiling the nitrate of mercury upon an excess of a powder composed of equal parts of bisulphate and bichloride of mercury; the liquor only, remaining after cooling, is used.

Aluminium Deposit.—This is an uncertain metal to make an electro deposit with. The following is said to be reliable: 50 parts by weight of alum, dissolved in 300 of water, and to this are added 10 parts aluminium chloride. Heat to 200° F., then cool. When cold add 39 parts cyanide of potassium. A feeble current is best.

Antimony Deposits.—(*a*) This has all the brightness of polished cast iron. Its dead lustre is a slate grey, and it may be easily scratch-brushed and polished; it resembles black platinum, and may take its place in many cases. Boil for an hour, in a porcelain dish or enamelled cast-iron vessel: 2¼ gal. water, 70 oz. soda carbonate, 17½ oz. finely-powdered antimony sulphide. Filter the boiling solution through paper or fine cloth; by cooling it deposits a reddish-yellow powder of antimony oxysulphide. Boil this powder again in the same liquor, and the new solution is the antimony bath. It is necessary to use the bath constantly boiling. For the anode, use either a plate of antimony or a platinum wire.

(*b*) Copper may also be covered with a layer of antimony by the following process: Dissolve antimony chloride in alcohol, and add hydrochloric acid until the mixture becomes clear; clean the copper well, and leave it in the bath for ¾ hour. The effect of the alcohol is thus explained: it moderates the precipitation of one metal from its solution by another metal, and causes the precipitate to fall in an extremely divided state; when alcohol is used alone, without water, the coating of copper thrown down is reduced to the last degree of tenuity. It is recommended that when the work is finished it should be well washed, first in water, and afterwards several times successively with a solution of soda carbonate, and with weak hydrochloric acid, and finally carefully dried in a warm place.

Bismuth Deposits. — Bertrand has succeeded in producing a galvanic deposit of bismuth on the surfaces of other metals. He uses a double chloride of bismuth and ammonia. The operation is performed cold, with a solution containing 25–35 gr. of chloride per litre. A single Bunsen pile should be used. On coming out, the objects are coated with a dark-looking slime, beneath which the sheen of the bismuth may be detected. The latter adheres very closely to the subjacent metal, and takes a fine polish, the colour being intermediate betwixt antimony and old silver.

Brass Deposits.—All the manufactures of bronze composition made of zinc or cheap alloys, have a brass deposit placed on before the bronze lustre is given, as the bronzing operation is more easy and satisfactory upon brass deposits. The preliminary and finishing operations and the disposition of the baths are the same for brass as for copper deposits. Heat is employed for brass deposits by those who electroplate coils of iron or zinc wire with this alloy. The proper temperature varies from 130° to 140° F., and the coils of wire dip only one-half or two-thirds of their diameter into the bath. The bath is put into an oblong open iron boiler heated by fire, steam, or hot water. The inside is lined with brass sheets connected with the positive pole of a battery. A stout copper or brass rod, in the direction of the length of the boiler, rests upon the edges, and the contact of the two metals is prevented by pieces of rubber tubing. The rod is connected with the negative pole by a binding screw. Remove the binding wire from the coils, and loosen the wires, bending the ends together into a loop. Dip the wire in a pickle of dilute sulphuric acid, and hang it on a strong round peg held in the wall so that the coil may be made to rotate easily. After a scrubbing with wet, sharp sand and a hard brush, give the coil a primary deposit of pure copper. It is then suspended from the horizontal rod over the brass bath, where only a part of the coil at a time dips into the solution and receives the deposit; the coil must be turned now and then ½ or ¼ of its circumference: by dipping the coil entirely into the liquid, the operation is not so successful. The wires are washed, dried in sawdust, and then in a stove, and lastly passed through a draw-plate, to give them the fine polish of true brass wire. Copper and brass wires are also covered with brass electro-deposits, in order to give them various shades.

Solutions for Baths.—(*a*) The ordinary potassium cyanide is often preferred to the pure article, on account of its lower price; but the real value and dissolving property of ordinary cyanide are very variable. The following is a general method by which a bath of brass may be prepared with any kind of cyanide. Dissolved together, in 2 gal. water, 8 oz. copper sulphate, and 8–10 oz. zinc sulphate. (*b*) 4 oz. copper acetate, with 4–5 oz. fused zinc protochloride ; and add a solution of 30 oz. soda carbonate, which produces a precipitate of copper and zinc carbonates ; allow this to settle ; then decant the supernatant liquor, and replace it by fresh water two or three times, after as many settlings. Then pour on 2 gal. of water containing, in solution, 30 oz. soda carbonate, and 15 oz. soda bisulphite ; while stirring with a glass or wooden rod, add ordinary potassium cyanide until the liquor is perfectly clear, or until nothing but the greyish-black iron, found in the cyanide, or the brown-red iron oxide in the zinc sulphate, remains in suspension. An additional quantity of about 1 oz. of ordinary cyanide improves the conducting power of the liquor.

(*c*) *Cold, for all Metals.*—Copper and zinc carbonates, recently prepared, each 4 oz. ; soda carbonate, in crystals, soda bisulphite, and potassium cyanide, pure, each 8 oz. ; and $\frac{1}{10}$ oz. white arsenic ; water, about 2 gal. This bath is prepared as follows : Dissolve in 3 pints water, 5 oz. copper sulphate, and 5 oz. crystallised zinc sulphate, and add a solution of 14 oz. soda carbonate in 1 qt. water. A greenish precipitate of mixed copper and zinc carbonates is formed : stir well, and allow to deposit for several hours. The supernatant liquid, holding the useless soda sulphate, is thrown away, and replaced by nearly 2 gal. water, in which are dissolved the bisulphite and carbonate. Dissolve together in the remaining warm water the potassium cyanide and the arsenious acid, and pour this liquor into the former one, which is rapidly decolourised, and forms the brass bath. Filter if necessary. Arsenious acid causes the deposit to be bright, but if in too great a proportion may give a white or steel-grey colour to the metal. This inconvenience is slight, as the yellow colour soon predominates. The arsenious acid may be replaced by soluble arsenites of potash, soda, or ammonia, but the proportions must be doubled. The baths for cold plating are generally placed in wooden tanks lined inside with gutta-percha, which resists their action for a long time. The sides of the tank are also lined with one or more brass sheets joined together, connected with the last carbon or copper of the same battery, the intensity of which is regulated by the surface of the articles to be plated. The articles are suspended by copper or brass hooks to stout rods of the same metal, all connected with the last zinc of the battery.

(*d*) *For Iron and Tin.*—Dissolve together in 14 pints pure water : 7 oz. soda bisulphite, 17 oz. potassium cyanide No. 2, 34 oz. soda carbonate. To this solution add the following, made in 3½ pints water : 4½ oz. copper acetate, 3½ oz. neutral zinc protochloride. The two liquors become colourless when mixed. Ammonia must not be used for brass plating baths for iron, especially for solutions worked in the cold.

(*e*) A colour resembling brass is given to small articles of iron or steel by a long stirring in a suspended tub, containing 1 qt. water, and of copper sulphate and tin protochloride crystallised, about ⅛ oz. each. The shades are modified by varying the proportions of the two salts.

(*f*) *For Lead and Pewter.*—Lead and pewter should be cleansed in a solution of about 4 oz. nitric acid to 1 gal. water, in which they remain for ½ hour. Pewter is more easily coated with brass than lead, but the same bath may be used for either. They are then rinsed, scoured with sand, and rinsed again. A good battery power and a large surface of anode are necessary, especially at the beginning of the deposit. The proper temperature of the bath for brassing lead, pewter, and tin is about 90° F. Stirring articles in a brass bath has a tendency to cause the deposition of copper alone.

(*g*) *For Zinc.*—Pure water, 4½ gal.; soda bisulphite, 24½ oz.; potassium cyanide, No. 2, 35 oz. Add the following solution: Water, 9 pints; copper acetate and zinc protochloride each 12½ oz.; ammonia, 14 oz. The filtered bath is colourless, and gives, under the action of the battery, a brass deposit of a very fine shade, varying from red to green, by increasing the proportion of copper, or that of zinc. The anode is of brass.

Arrangement of Bath.—In the disposition of the baths for brass plating, it is always necessary to have all the articles suspended at about equal distances from the anodes; the bath may be subdivided by several anodes forming partitions, so that each loaded rod is between two anodes, or smaller separate baths may be employed. The anodes should be removed when the bath is not at work. In order that the brass-plating of zinc and copper may be lasting, the deposit must not be too thin, and must be scratch-brushed, rinsed in water slightly alkaline by quicklime, and thoroughly dried in a stove. But generally the articles are brass-plated by remaining in the bath for 10–25 minutes. Cast and wrought iron, lead and its alloys, require brass solutions richer in the metals than when depositing upon zinc or its alloys. The battery power should also be greater.

Correcting Bath.—The losses of the solution are to be repaired by additions of copper and zinc salts, and arsenious acid dissolved in potassium cyanide. The operator will determine the needed substance from the rapidity of the deposit, its colour and so on. If the deposit is too slow, try whether the bath will absorb the salts of copper and zinc without the addition of cyanide. If the coat of brass has an earthy and ochreous appearance, and especially if the liquor is blue or green, add potassium cyanide until perfect decolourisation takes place. If the deposit is dull and unequal add a small quantity of arsenious acid dissolved in cyanide. If the deposit is too red, add the salt of zinc, alone, or dissolved in cyanide. If the deposit is too white, or of a greenish-white colour, add the salt of copper, alone, or dissolved in cyanide. When the bath, after long use, has become over-loaded with salts, the specific gravity is too great for the easy passage of the electric current, the liquor must be diluted with water until it works satisfactorily. The specific gravity of a brass bath may vary from 5° to 12° B. The pieces, before brass-plating, must be perfectly cleansed in the same manner as zinc or iron; if the brass deposit is irregular, remove the objects from the bath, rinse, scratch-brush, and put again into the bath until the colour and the thickness of the deposit are satisfactory. Scratch-brush again, and, if necessary, rinse in hot water, dry in warm sawdust of white wood, and put in the stove-room. The last three operations are indispensable for hollow pieces.

Colour of Deposit.—The difficulty in brass plating, especially with small baths, is in keeping uniform the colour of the deposit, as the galvanic current, having simultaneously to decompose two salts, each offering a different resistance, must, according to its intensity, vary the composition and the colour of the deposited alloy. It will be found that a feeble current principally decomposes the copper salt, and results in a red deposit; whilst too great intensity in the current decomposes the solution of zinc too rapidly, and the deposit is a white or bluish-white alloy. This is the case more especially with newly prepared baths, and is an indication of irregularity in the conducting power of the bath, which, however, becomes more regular after being used for some time. The inconvenience of a red deposit may be remedied by increasing the number of the elements of the battery, or employing stronger acids, or decreasing the number and the surfaces of the objects to be plated;

the other inconvenience of white deposits will disappear by diminishing the number of elements, or by increasing the surfaces to be covered. The deposit may also be modified by substituting for the brass anode, either a sheet of pure copper, or one of zinc, or by simply hooking one of these sheets to the brass anode. A bath of pure copper will be transformed into one of brass by the use of a zinc anode; and a bath of brass will become one of copper by the aid of a copper anode.

Cobalt Deposits.—(*a*) The most beautiful cobalt plating may be obtained upon brass and copper, by employing in the battery—with two Bunsen cells—a moderately concentrated solution of the double chloride of ammonium and cobalt. This solution is prepared by dissolving 40 grm. crystallised cobalt chloride, and 20 grm. ammonium chloride in 100 c.c. water, with the addition of 20 c.c. ammonia.

(*b*) *By Contact.*—While nickelling by touching with zinc yields only incomplete results, the electro-plating with cobalt of copper and brass articles succeeds very well with the use of the following bath: Crystallised cobalt sulphate, 0·35 oz.; crystallised sal-ammoniac, 0·7 oz.; water, 1 quart. Heat the bath to between 104° and 122° F., and immerse the previously cleansed and pickled articles in the bath, bringing them in contact with a bright zinc surface; for small articles a zinc sieve may be used. In 3 or 4 minutes the coating is thick enough to bear vigorous polishing.

Copper.—Electro-deposits of copper are obtained by decomposing a double salt of copper with another base, such as the double cyanide of potassium and copper. This process is equally well adapted to all metals, and the deposits are fine, lasting, and their thickness is entirely regulated by the will of the operator.

(*a*) Dissolve about 16 oz. copper sulphate in 2 gal. water, and add a solution of soda carbonate until no more precipitate is formed; collect the green precipitate, copper carbonate, thus obtained upon a cloth filter, and wash it several times with water; then stir the washed copper carbonate in water, to which potassium cyanide is added until the carbonate is entirely dissolved, and the solution is colourless. It is well to add a small excess of cyanide, which will increase the conducting power of the liquor. This bath may be employed hot or cold, and requires an intense electric current for its decomposition. A copper plate or foil forms the anode, and as it slowly dissolves nearly makes up for the loss of copper in the bath which has deposited on the negative pole. The anode must be removed when the bath does not work, because it will be dissolved even without an electric current, and the bath having been overcharged with copper, which is indicated by a blue or green colour, will require a fresh addition of cyanide to be in good order. This bath is neither economical nor very reliable. The following formula is preferable:—

(*b*) Water, 2 gal.; copper acetate, crystallised; soda carbonate, crystals; soda bisulphite; potassium cyanide, pure, 7 oz. each. For this bath the copper acetate is put first into the vessel, and moistened with sufficient water to make a homogeneous paste. This salt, like flour, is wetted with difficulty, and will float on the surface of too great a body of water. The soda carbonate and some water are added to this paste, and, after stirring a light green precipitate is formed; 3 pints more water are then added with the soda bisulphite, and the mixture becomes of a dirty yellow colour. Lastly, and the remainder of the water and the potassium cyanide. The electro-copper bath must be colourless. If, after the complete solution of the cyanide, the liquor is not entirely colourless, add more cyanide. If a perfectly limpid bath is desired, pass it through filtering paper, or decant it after settling. This bath requires an electric current of mediate intensity for its decomposition. The copper anode should have a surface nearly equal to that of the immersed objects. Large pieces are generally kept hanging and motionless in the bath, whilst small articles are moved as much as possible, which is always to be preferred, especially with warm baths. If it were always possible to obtain pure potassium cyanide, this formula would be satisfactory in every case. But it is very difficult to find a perfectly satisfactory potassium cyanide. The following formulæ require a cyanide containing from 70 to 75 per cent. of the real article :—

(*c*) *Cold Bath for Iron and Steel.*—Soda bisulphite and potassium cyanide, 18 oz. each ; soda carbonate, 36 oz.; copper acetate, 17 oz.; aqua ammonia, 12½ oz. ; water, 5½ gal.

(*d*) *Warm Bath.*—Soda bisulphite, 7 oz. ; potassium cyanide, 25 oz. ; soda carbonate and copper acetate, 18 oz. each ; aqua ammonia, 10 oz. ; water, 5½ gal.

(*e*) *Hot or cold Bath for Tin, Cast Iron, or Large Pieces of Zinc.*—Soda bisulphite, 10 oz. ; potassium cyanide, 18 oz. ; copper acetate, 12½ oz. ; aqua ammonia, 7 oz. ; water, 5¼ gal.

(*f*) *For small articles of zinc* which are coppered in a perforated ladle, and in nearly boiling baths : Potassium cyanide, 25 oz.; soda bisulphite, 3½ oz.; copper acetate, 16 oz. ; aqua ammonia, 5¼ oz. ; water, 4–5½ gal. To prepare these different baths, dissolve all the salts in about 4 gal. distilled water, except the copper acetate and the ammonia, which are dissolved apart in the remaining gallon. These two solutions are mixed, and that of copper and ammonia, which was of a magnificent blue, must become entirely colourless. When the liquors are not colourless there is a deficiency of potassium cyanide, which must be added until entire decolourisation takes place. The bath is ready to work when subjected to the action of the electric current.

The cold baths are put into well-joined tanks of oak or fir wood, lined inside with gutta percha. The vertical sides are also covered with sheets of copper, which act as the soluble anode, and reach to just below the top edge of the tank. This anode is connected by the clean extremities of a conducting wire to the last copper or carbon —that is to say, to the positive pole. Fix a stout brass wire upon the top of the tank, without any point of contact with the soluble anode, and connect by a second wire with the last zinc or negative pole of the same battery. The objects to be coppered are suspended in the bath by copper wires, supported themselves upon a stout, clean, brass, rod, the two extremities of which rest upon the brass conducting wire fixed upon the tank. Several of such rods are placed parallel to each other, and great care must be taken to prevent any contact with the anode, because the working of the bath would then be immediately stopped. When the thickness of the deposited copper is very small, the coat is sufficiently bright to be considered finished after drying. But if the operation is more protracted, the deposit has a more or less dead lustre on account of its thickness, and, if a bright lustre is desired, we must use the scratch-brush.

The hot baths are put into stoneware vessels heated in a water or steam bath, or into an enamelled cast-iron kettle placed directly over a fire. The insides are also lined with an anode of copper connected with the positive pole of the battery, and the edges of the vessels are varnished, or support a wooden ring upon which rests a brass circle communicating with the negative pole. The objects to be electroplated hang from this circle. The hot process is much more rapid than the cold, and is especially adapted to those articles which are difficult to cleanse, because any remaining greasy substance is dissolved by the alkaline bath.

Parcels of small articles are not suspended in the bath ; they should be connected with the negative wire in the hand of the operator, and stirred about in every direction in the bath. This agitation permits of the employment of an intense current, without danger to the beauty of the deposit. Small articles of zinc are placed in a stoneware perforated ladle, at the bottom of which is attached a zinc or copper wire, which is wound up around the handle, and is connected with the negative pole of the battery. It is sufficient that one of the small articles touches the wire for all of the others to be affected by the current, as they are in contact with each other. If the bottom of the vessel is metallic, the ladle is made to rest upon a porcelain or stoneware ring. During the operation the articles are often jerked in the ladle ; this agitation changes the position and the points of contact of the objects. When the deposit is being made too slowly, bring up the bath by the addition of equal weights of copper acetate and potassium cyanide.

(*h*) *For Silver.*—Large pieces of silverware may be coppered in these baths. Very small articles are simply threaded upon a zinc or iron wire, or placed in a perforated ladle with granules or cuttings of either of these metals. Place the whole for a few minutes in a dilute but very acid solution of copper sulphate, the zinc or the iron is dissolved, and the copper is deposited upon the silver. When the article is intended to be gilded or silvered, it is immediately passed through the solution of nitrate of mercury, rinsed in cold water, and placed in the electro-baths, without drying or scratch-brushing.

(*i*) *Coppering Iron.*—To copper iron, after having thoroughly cleaned and polished the articles, they must be plunged in a potash bath, to remove all traces of grease, rinsed, and immediately transferred into a bath containing cyanide of copper. This is best made by dissolving sulphate of copper in hot rain-water in the proportion of ½ lb. to the quart. When cold, liquor ammonia fort. is to be added with constant stirring. A green precipitate forms at first, which redissolves as more ammonia is added, when the solution becomes clear, and of a beautiful amethystine blue colour. When this point is reached, add an equal bulk of rain-water, and then a strong solution of cyanide of potassium in sufficient quantity to turn the colour from blue to that of pale ale. Set aside to settle, pour off the clear, and add thereto sufficient water to make up 1 gal. Use a copper anode, and send a current of about 8 volts pressure through the bath. ('English Mechanic.')

(*j*) Dissolve 4 oz. of sulphate of copper (bluestone) in 1 pint of hot rain-water. When cool add liquid ammonia until solution is quite blue. Stir well with glass rod. Dilute this with 1½ pint of cold rain-water, and add to it solution of potassium cyanide whilst stirring until solution is of a dark-brown colour. Filter this, and add rainwater until you have ½ gal. of solution. This can be used cold. Fill a glass or glazed earthenware vessel with this solution, and hang into this (on a copper wire) the articles to be plated, and connect to negative pole of battery. This is called the cathode. The positive pole is connected to a pure copper plate (the anode), and immersed into the solution near the articles to be plated. Employ E.M.F. of about 3 volts. To nickel-plate cycles, first deposit copper, as described before, and when evenly coated, nickel-plate in a good nickel-salt solution, which can be bought of any respectable firm at about 10*d*. per lb., together with a pure nickel plate for anode. ('English Mechanic.')

(*k*) *Iridescent Copper on Iron.*—The method of coating iron with copper in such a manner that the film of deposited metal shall give the appearance of iridescence is thus described by Dr. Weil : 35 parts crystallised cupric sulphate, or an equivalent amount of any other salt of copper, are precipitated as hydrated oxide by means of caustic soda ; the oxide is added to a solution of 150 parts Rochelle salt, and dissolved in 1000 parts water. To this 60 parts best caustic soda, containing about 70 per cent. NaO, is added, when a clear solution of copper will be formed. Other alkaline tartrates may be substituted for the Rochelle salt above mentioned, or even tartaric acid may be employed, but in the case of tartaric acid or acid tartrates a small additional quantity of caustic alkali must be added, sufficient to saturate the tartaric acid or acid tartrate. Oxide of copper may also be employed precipitated by means of hypochlorite of soda, but in all cases the proportions between the copper and the tartaric acid should be maintained as above, and it is advantageous not to increase to any notable extent the proportion of the caustic soda. The object to be coppered is to be cleaned with a scratch-brush in an alkalino-organic bath, attached to the cathode, immersed in the coppering bath, and treated with the usual precautions, when it will become rapidly coated with an adherent film of metallic copper. As the bath gradually loses its copper, copper oxide as above prepared should be added to maintain it in a condition of activity, but the quantity of copper introduced should never exceed that above prescribed as compared with the quantity of tartaric acid the bath may contain. If the quantity of copper notably exceeds this proportion, certain metallic irisations are produced on the surface of the object. These effects may be employed for ornamental and artistic purposes. According to the time of the immersion, the strength of the current, and the proportion of copper to the tartaric acid, these iridescences may be produced of different shades and tints, which may be varied or intermingled by shielding certain parts of the object by an impermeable coating of paraffin or varnish, while the iridescent effect is being produced on the parts left exposed. All colours, from that of brass to bronze, scarlet, blue, and green, may be thus produced at will.

(*e*) *For Zinc.*—The use of cyanide baths for plating on zinc has the double disadvantage of being poisonous and expensive. Hess overcomes the objections by rendering the cyanide bath unnecessary. This he accomplishes by the use of an organic salt of copper, for instance a tartrate. Dissolve 126 grm. copper sulphate (blue vitriol) in 2 litres water; also 227 grm. potash tartrate and 286 grm. crystallised soda carbonate in 2 litres water. On mixing the two solutions a light bluish-green precipitate of copper tartrate is formed. It is thrown on a linen filter, and afterwards dissolved in ½ litre caustic soda solution of 16° B., when it is ready for use. The coating obtained from this solution is very pliable, smooth, and coherent, with a fine surface, and acquires any desired thickness if left long enough in the bath. Other metals can also be employed for plating in the form of tartrates. Instead of tartrates, phosphates, oxalates, citrates, acetates, and borates of metals, can be used, so that it seems possible to entirely dispense with the use of cyanide baths.

Gold Baths.—(*a*) Distilled water, 2½ gal.; potassium cyanide, ordinary 70 per cent., 10½ oz.; pure gold, 3½ oz.; aqua ammonia, 17½ oz. Heat the gold in a glass flask with 9 oz. pure hydrochloric acid, and 4½ oz. pure nitric acid. When the gold is dissolved, continue the heat in order to expel the acid fumes, and until the colour of the liquid is dark red, nearly black. Remove from the fire, and dissolve the crystalline mass formed in cooling in 3–4 pints water, and pour into a large porcelain dish. Add the ammonia, which produces an abundant yellow precipitate of gold ammonium; pour upon filtering paper, and the filtering liquid, which still contains traces of gold, is kept with the saved waste. Wash the precipitate remaining upon the filter several times with cold water, until it no longer smells of ammonia. It must not be dried, as it is a fulminating mixture, and consequently very dangerous. Next dissolve in the vessel used as a bath the potassium cyanide in the distilled water. Filter, and add the wet gold ammonium, which rapidly dissolves when stirred, and forms a clear gold bath. But before using it cold, the ammonia should be expelled by boiling for about one hour. For a newly-prepared cold electrogilding bath, the ordinary potassium cyanide is preferable, on account of the potash it contains, which renders the liquor a better conductor of electricity. But for the preservation of the strength, the pure cyanide is better, as it possesses the advantage of a constant composition, and does not load the solution with foreign salts. The gold solution for maintaining the metallic strength of the bath is prepared as follows: Transform the gold into precipitate of gold ammonium, as above described, place it in water, 2 pints water to 4 oz. gold, then add potassium cyanide until the liquor is colourless. If there is not sufficient water with the gold ammonium, the liquor will be dark red, and will not be decolourised by cyanide.

(*b*) Distilled water, 2½ gal.; potassium cyanide, pure, 7 oz.; or ordinary cyanide, according to strength, 10–14 oz.; pure gold, 3½ oz. Make a neutral gold chloride, as in the preceding formula, and, when cold and crystallised, dissolve it in 3½ pints water. Filter if needed. Dissolve the cyanide in 14 pints water; filter, and mix the two solutions, which become colourless. When it is possible to boil this bath for ½ hour before using it, it becomes a better conductor of electricity, and the gilding is more uniform. Its strength is maintained by additions of neutral gold chloride and pure potassium cyanide, 1–1½ pure cyanide, to 1 of gold. Both the above baths may be diluted with once or twice their volume of water; the gilding will remain fine, but the proportion of gold deposited will be less in a given length of time.

(*c*) Yellow prussiate of potash, 7 oz.; pure potash carbonate, 5 oz.; sal-ammoniac, 1 oz.; pure gold transformed into chloride, ½ oz.; water, 2½ gal. Boil all the salts together, less the gold chloride, separate by filtration the precipitate of iron carbonate, then add the gold chloride dissolved in a little water, and allow the bath to cool off. Any kind of gold salt, and the oxide, or even finely-powdered metal, may take the place of the gold chloride; but the latter is preferred on account of the facility of its preparation, and of its solubility. Any kind of gold salt will be transformed into cyanide by the potassium cyanide. The small proportion of the potassium chloride resulting from the transformation of the gold chloride into cyanide does not prevent the good working of the baths. The addition of a little prussic acid produces a brighter, but thinner gilding. The indicated cyanides may be replaced by the cyanides of sodium, calcium and ammonium.

(*d*) Cold gilding baths are generally kept in porcelain or stoneware vessels; but for large volumes of liquor, use wooden troughs lined with gutta-percha plates. The sides of the troughs support anodes of laminated gold, which dip entirely into the liquor, and are held by small platinum wires; they are connected with the positive pole of the battery. Suspend the articles by means of metallic slinging wires to a movable frame of clean brass rods connected with the negative pole. The deposit of gold should be pure yellow, but it has sometimes a dull earthy grey colour. In that case, scratch-brush it with the greatest care, and then pass it through the or-molu colouring. The gold anode conducts the electricity, and also maintains the metallic strength of the bath up to a certain point; but it is necessary to add now and then either oxides or chloride of gold, and a certain proportion of potassium cyanide, to make up for that transformed into potash carbonate and ammonia cyanide. The proportion of cyanide is about double that of the gold chloride added; this is ascertained by the colour of the bath and the shade of the deposit; if the proportion of the gold chloride is too great, add more cyanide. If gold predominates, the deposit is quite black or dark red; when the cyanide is in excess, the gilding is very slow and grey, and it will sometimes happen that pieces already gilt will lose their gold. When the bath is not in use, the gold anode must be removed from it, otherwise it will be dissolved. If the anode were partly immersed in the bath, it would be rapidly cut at the level of the liquid; for this reason use platinum wires, which are not acted upon. It is remarkable that the solution of cyanides, even without the action of the electric current, rapidly dissolve all the metals except platinum in the cold or at a moderate temperature, and that at the boiling-point they have scarcely any action upon the metals.

(*e*) *Cold Baths.*—Cold electrogilding should be done slowly; and it is necessary to often look at the pieces in the bath, and scratch-brush those with an irregular deposit, or with dark spots. The intensity of the current should be often changed by increasing or diminishing the number of the elements, or the strength or the volume of the liquors in the battery. With too much intensity in the current, the deposit is black or red; it is yellow with the proper amount of electricity. With a weak current those portions opposite the anode only get covered with gold; it is well to change the position of the objects often, in order that the deposit be regular. With a freshly-prepared bath, it may happen that surfaces already gilt will lose their gold by changing their positions. This is a sign that the bath contains too much cyanide, and too little gold, or that the electric current is too weak.

(*f*) When the deposit obtained in cold baths is unsatisfactory in appearance, although the quantity is sufficient, the proper shade may be imparted by: (1) The gilt article is steeped in a solution of nitrate of mercury, until it has become white. It is heated afterwards to volatilise the mercury, and scratch-brushed. (2) Place the article in concentrated sulphuric acid, then heat it until abundant white fumes are disengaged, throw it, still hot, into a weak pickle of sulphuric acid. In this case, the acid has destroyed the organic impurities which may exist in the deposit, and reduces the subsalts of gold to the metallic state. (3) Smear the article with a thick paste of water and powdered borax, or with lime biphosphate of the consistency of honey, and heat until igneous fusion takes place. Then put the article into dilute sulphuric acid, which dissolves the borax or the biphosphate, and leaves the gold with its natural bright lustre. When, after scratch-brushing small gilt articles, their colour is not entirely satisfactory, it may be improved by plunging the articles again into the bath but for an instant, and then immediately into boiling water. For gilding German silver, the solution should be worked at rather a low temperature, and with a less surface of anode. The solution should be just so weak in precious metal, that the German silver will not precipitate the gold without the aid of the battery; otherwise the deposit will take place so rapidly that the gold will peel off when being burnished or scratch-brushed.

(*g*) *Hot Baths.*—Gold electroplating in hot baths is more regular, more rapidly obtained, and possesses a deeper shade than that by cold baths. Crystallised soda phosphate, 21 oz.; soda bisulphite, 3½ oz.; pure potassium cyanide, ⅓ oz.; pure gold, transformed into chloride, ⅓ oz.; distilled water, 2⅕ gal. This is satisfactory for electrogilding silver, bronze, and other alloys rich in copper.

(*h*) For gilding wrought and cast iron and steel directly, without a previous coat of copper, the bath is modified as follows: Distilled water, 2⅕ gal.; soda phosphate, 17½ oz.; soda bisulphate, 4½ oz.; pure potassium cyanide, ⅙ oz.; gold transformed into chloride, ⅓ oz. The proportion of gold indicated is that of the metal employed, and it is not necessary to mind the weight of the chloride, if the proper amount of gold is dissolved in aqua regia: 10 parts metallic gold correspond to about 18 of neutral chloride, or to 22 of acid chloride such as is usually sold. Steel articles, after cleansing by alkalies, must be passed rapidly through a very dilute solution of hydrochloric acid, wiped, and dipped into a very hot bath with an intense galvanic current at the beginning, which is gradually diminished by partly withdrawing the platinum anode. Small articles of steel, such as pens, or watch hands are threaded on a thin brass wire, and separated one from the other by glass beads. After cleansing, they are put into the boiling bath, rinsed, dried, and polished in hot and dry sawdust. It is preferable to give zinc, tin, lead, antimony, or the alloys of these metals, a previous coat of copper, or to begin the gilding in a hot gold electro-bath, nearly worn out, and to scratch-brush the articles carefully. The gilding is completed in a new hot bath, with a strong current.

Put four-fifths of the distilled water into a porcelain dish, or an enamelled cast-iron kettle, heated over a charcoal stove, and dissolve in it, by the aid of stirring, the crystallised soda phosphate. When this is entirely dissolved, remove the liquor from the fire, filter if necessary, and allow it to cool off. Place the gold in a glass flask, with ½ oz. pure nitric acid and 1 oz. pure hydrochloric acid. Heat slowly until the gold has dissolved, and then more rapidly to expel the excess of acid. There should remain a thick liquid of a blackish-red colour. Remove the flask from the fire, and by cooling the contents form a brown-red crystalline mass. The cooling is important. Dissolve in a porcelain dish, in half the remaining water, the soda bisulphite and the potassium cyanide. Then dissolve the neutral gold chloride in the remaining water, and pour it slowly, stirring with a glass rod, into the cold solution of soda phosphate; add the solution of bisulphite and cyanide. The whole liquor soon becomes colourless; the bath is then ready. If the gold chloride were thrown into the solution of soda phosphate while hot there would be danger of a partial reduction of the gold in the form of a metallic powder.

The hot electrogilding baths for small quantities of liquor are kept in porcelain dishes, but for large baths use enamelled cast-iron kettles. The temperature may vary from 120°–175° F. Small articles, such as jewellery, are kept in the right hand with the conducting wires, and plunged and agitated in the bath. The left hand holds the anode of platinum wire, which is steeped more or less in the liquor, according to the surface of the articles to be gilt. Large pieces are suspended from one or more brass rods, and are not moved about. The gilding is very rapid, and a sufficient thickness is obtained after a few minutes. The shade of the gold deposit is modified by the amount of the platinum anode dipping into the liquor. If it dips but a little, relatively to the surface of the articles, the gilding is pale; by immersing it more, the shade will become deeper and deeper until it is red. The platinum anode is connected by a conducting wire to the positive pole of the battery, and the conducting wire starting from the negative pole, touches or supports the articles to be gilt. As a rule, it is preferable to replace the impoverished baths by fresh ones, instead of keeping up their strength by additions of metal, especially for small articles. When gilding large pieces, maintain the strength of the baths by successive additions of gold chloride, or, what is better, of equal parts of gold ammonium and pure potassium cyanide. In this manner baths may be made to last a long time, but they are open to the inconvenience of furnishing a red or green gilding, if many articles of copper or of silver have been gilt in them. Articles of copper, or its alloys, should be perfectly cleansed, and may be passed through a very diluted solution of nitrate of mercury.

(*i*) *Silver* requires to be heated, dipped, and perfectly scratch-brushed. For this metal the gilding should be strong, in order to prevent the corners and raised parts from becoming white and bare; and it is a good precaution to give it a coat of copper or brass, or a first gilding in an old bath. Soda phosphate, 14 oz.; soda bisulphite, 3½ oz.; potash bicarbonate and caustic potash, 1¾ oz. each; potassium cyanide and pure gold for neutral chloride, ½ oz. each; distilled water, 2⅙ gal. All the substances except the gold chloride may be dissolved together, and filtered if necessary; then the solution of gold chloride is added. This bath is heated to 120°–140° F. and produces a very fine gilding, but it requires an intense electric current. It does not suit for the direct gilding of iron or steel.

(*k*) Yellow prussiate of potash, 5¼ oz.; potash carbonate, pure, 1¾ oz.; ammonia hydrochlorate, ⅔ oz.; pure gold for neutral chloride, ⅓ oz.; water, 1 gal. Dissolve the first three salts in hot water, and filter the solution; after cooling add the gold solution, boil for ½ hour, taking care to replace the evaporated water.

(*l*) Distilled water, 17 pints; potash or soda pyrophosphate, 28 oz.; hydrocyanic (prussic) acid, ⅓ oz.; crystallised gold perchloride, ⅔ oz. The soda pyrophosphate is most generally employed, and is obtained by melting, at a white heat, the ordinary crystallised soda phosphate. The soda pyrophosphate may be obtained in the form of crystals, which is a proof of definite composition. The quantity of chloride represents a little more than ⅓ oz. pure gold treated by aqua regia. Put 16 pints distilled water in a porcelain vessel, or an enamelled cast-iron kettle, and add, by small portions at a time, and stirring with a glass rod, the pyrophosphate; heat, filter, and let it cool down. The gold chloride is prepared by introducing into a small glass flask pure gold finely laminated, ⅓ oz.; hydrochloric acid, pure, nearly 1 oz.; nitric acid, pure, ½ oz. The flask is slightly heated, effervescence and abundant nitrous vapours result, and in a few minutes the gold has entirely disappeared, leaving a reddish-yellow liquor. The flask is then put upon a sheet of iron, with a hole in the centre, and supported by a tripod. The whole is heated by a gas or spirit lamp to evaporate excess of the acids; too much acidity may cause great irregularities in the working of the bath, and even prevent its action altogether. An excess of nitric acid causes a jumping of the heated liquors, and may overthrow the whole; it is preferable to have the hydrochloric acid predominating. The evaporation is finished when vapours escape slowly from the flask, and when the liquid has become of an oily consistency and of a deep red colour. The flask is then removed from the fire by wooden pincers, and set to cool upon a ring of plaited straw. If a more rapid evaporation is desired, heat the flask over ignited charcoal, or the spirit lamp; agitate the liquid to prevent any of the gold from returning to the metallic state. Well-prepared gold chloride, when cold, forms a saffron-yellow crystalline mass. If the colour is red, it has been too much evaporated, and will do very well for electro-baths, but for dipping baths it must be heated again after a small addition of the two acids. If the gold perchloride, by too protracted a heat, has passed to the state of insoluble protochloride, or even of metallic gold, the treatment must be begun again with the indicated mixture of pure nitric and hydrochloric acids. The perforated sheet of iron, upon which the flask rests, is intended to prevent the action of heat upon the sides of the vessel, which will decompose the films of gold chloride wetting the flask at these places. When the gold chloride is cold and crystallised, dissolve it in the flask with a little distilled water, and pour the solution through a paper filter held in a glass funnel into a clean bottle; this is to separate a small quantity of silver always found in the gold of the trade. Rinse the flask and filter with the unemployed water, so as to get all the gold into the bath. Pour the filtered solution of gold chloride into the cooled one of pyrophosphate, and stir with a glass rod. Lastly, add the hydrocyanic acid, and the bath is heated nearly to the boiling point for use. If the solution of pyrophosphate is still tepid, add the hydrocyanic acid before the gold chloride. Hydrocyanic (prussic) acid is not absolutely necessary; but, without it, the bath is too easily decomposed, and the gold is too rapidly precipitated upon the objects placed in it. When the solutions are mixed in the cold, the liquor is yellow or greenish-yellow; but becomes colourless by the increase of temperature. If the liquor becomes violet, it is an indication that there is too little hydrocyanic acid; add it, drop by drop, until the liquor becomes colourless. An excess of this acid is objectionable, but there is a very simple method of keeping the baths in good working order, by adding prussic acid gradually to those too rich in gold; or correcting any excess of prussic acid with a small proportion of gold chloride, until the gilding is produced without difficulty and of the proper shade. Thus prepared, the bath will produce very fine gilding upon well-cleansed articles, which must also have passed through a very diluted solution of nitrate of mercury, without which the deposit of gold is red and irregular, and will not cover the soldered portions. The articles are supported by a hook or in a stoneware ladle perforated with holes, or in brass gauze baskets; they must be constantly agitated whilst in the bath. Gilders usually employ three baths, placed in close proximity to each other, and heated upon the same furnace; the first bath is one deprived of gold by a previous operation, and is used for removing all excess of acid which may remain upon the articles: the second bath still retains some gold, but not enough to give a sufficiently rich gilding. The pieces passed through it begin to receive the deposit, which will be finished in thickness and shade in the third bath. A gas furnace, easy to manage, and clean in its working, may be arranged by having a properly supported sheet-iron plate, with holes cut out where the kettles are to stand. Under each kettle place suitable gas burners; when the baths have been heated nearly up to boiling point, lower the gas, so as not to increase the temperature. This method produces much more gilding with a given quantity of gold, than one bath alone. The gilding is done in a few seconds; the finishing operations consist in rinsing in fresh water, drying in dry and warm sawdust, and burnishing, if desired.

(*m*) The following solution, to be used at a temperature of 120°–180° F. is recommended by Rod: Crystallised soda phosphate 60; soda bisulphate, 10; potassium cyanide, 1; gold chloride, 2½; distilled or rain water, 1000 parts by weight. To prepare this bath properly, the water should be divided into three portions, viz. one of 700 parts and two of 150 parts. The sodic phosphate is dissolved in the first portion, the gold chloride in the second, and the soda bisulphate and potassium cyanide in the third. The two first portions are gradually mixed together, and the third is afterwards added. With this solution Rod uses a platinum anode (a wire or strip), adding fresh portions of the gold salt as the solution becomes exhausted.

(*n*) Dr. Ebermayer gives a formula for gilding metallic articles so as to look like polished gold, by simply dipping them into a warm solution. Dissolve 10 grm. gold in 40 grm. hydrochloric acid and 15 grm. nitric acid; stew down, letting as much of the acid escape as possible; then throw down the gold as fulminating gold by means of spirit of ammonia; filter, and wash. In the meantime dissolve 100 grm. potassium cyanide in as little water as possible, and then dissolve the gold upon the filter with the cyanide solution. Pour this solution again and again over the filter until all the brown particles are dissolved, when the gilding solution is prepared by the addition of 1 litre distilled water. Into this solution, while warm, dip the metallic object to be gilded, and when drawn out it will have all the appearance of polished gold.

(*o*) This bath should be employed only as a complement to the cleansing process, before a more resisting gilding, as its results have little durability. Water, 2 gal.; potash bicarbonate, 7 oz.; caustic potash, 63 oz.; potassium cyanide, 3 oz.; metallic gold to be transformed into chloride, $\frac{1}{5}$ oz. The whole is brought up to the boiling point, and a pale gilding is obtained even upon articles imperfectly cleansed, and without using nitrate of mercury. It is possible to add $\frac{1}{5}$ oz. gold chloride several times to this bath without any other substance. Afterwards maintain it at the proper strength by additions of gold and salts in the above proportions, and it will last for an indefinite period. This bath will gild about 140 oz. of small jewellery with $\frac{1}{30}$ oz. gold, whereas a pyrophosphate bath gilds only about 35 oz. of small articles with the $\frac{1}{30}$ oz. gold extracted from the liquor.

Dissolving Gold in Aqua Regia.—Take aqua regia, composed of 2 parts of nitric acid, and 1 of muriatic acid; or of 1 part sal-ammoniac, and 4 of aqua fortis; let the gold be granulated, put into a sufficient quantity of this menstruum, and exposed to a moderate degree of heat. During the solution, an effervescence takes place, and it acquires a beautiful yellow colour which becomes more and more intense, till it has a dark golden or orange colour. When the menstruum is saturated, it is very clear and transparent.

Management of Hot Baths.—The baths may be more concentrated, the quantity of water may be diminished, without changing the proportions of the salts and of the gold. But it is preferable to use dilute solutions, which deliver the metal in smaller quantity in a given time, but more homogeneous in substance. The articles should be kept in constant agitation; there is then no difference of specific gravity among the layers of the liquor, and the gilding possesses a uniform colour. A foil or a wire of platinum is preferred to a soluble anode of gold when electro-gilding by the aid of heat, as it is not dissolved, and is more handy for regulating the intensity of the current, by immersing it more or less in the liquid. Thus with the same bath and battery three different shades can be obtained; a pale colour, with the anode dipping but slightly; a yellow colour, when the immersion is greater, and a red gold, if the whole anode is in the liquor. In a bath of pink gold, composed of gold, copper, and silver, by increasing or diminishing the length of the platinum anode in the liquor, the deposit will have a white, yellow, or red shade, as the various metals require different degrees of intensity for their reduction in the galvanic current.

Colouring.—If the gilding is dull and irregular in colour, melt together in their water of crystallisation, at about 212° F., equal parts of iron, zinc, alumina and potash sulphates, and saltpetre. Cover the articles with the mixture, and put them into a cylindrical and vertical grate. This is placed in the centre of a furnace, where the charcoal burns between the sides and the grate which holds the articles. When the moistened finger is presented to one piece and a slight hissing sound is heard, the heat has been sufficiently raised; put all the articles rapidly into very dilute sulphuric acid, where the coating of salts is quickly dissolved; the articles present a warm, uniform shade of colour. If the copper articles are not entirely gilt by the first operation, the ungilt portions will show themselves by a red colouration, and the articles must then be deprived of gold, cleansed, and gilt anew. Sometimes when the first gilding is imperfect, instead of colouring by the process just described the articles are placed for a few moments into the electro-bath. For articles which require a good plating there is an easy method by this process of obtaining as good results as by the battery; it consists in gilding several times, by dipping; before each dipping, the article is passed through solution of nitrate of mercury. Gilding by dipping is superior to that by electricity in depth of shade, brightness, and especially in not scaling off, as the deposit is of pure gold only.

Green and White.—(*a*) These shades may be graduated at will, and are obtained by adding, drop by drop, until the desired shade is arrived at, to the bath of double pyrophosphate of soda and gold, a solution of silver nitrate. For the solution of silver nitrate, dissolve in 5 oz. distilled water ½ oz. silver nitrate, crystallised, or lunar caustic. Before gilding green or white, yellow gild the objects in the ordinary bath, then pass them rapidly through the mercurial solution, and, lastly, dip them into the gold bath holding the silver nitrate, which parts rapidly with its silver upon the first articles steeped in it. It is necessary to maintain the constancy of the shade by the addition of a few drops of the silver solution when required.

(*b*) Add to one of the above baths a solution of the double cyanide of silver and potassium, until the desired shade is obtained. The tints will vary from a leek-green to a very pale whitish-yellow. This kind of gilding mixed upon the same articles with red, yellow or pink gold, will produce splendid effects of contrast, especially upon chased parts, where the green gold has a velvety lustre.

(*c*) 1 oz. 10 dwt. saltpetre; 1 oz. 4 dwt. sal-ammoniac; 1 oz. 4 dwt. Roman vitriol; and 18 dwt. verdigris. Mix them well together and dissolve a portion in water as occasion requires. The work must be dipped in these compositions, applied to a proper heat to burn them off, and then quenched in water or vinegar.

Red.—(*a*) Mix in suitable proportions the electro-copper bath already described with one of the baths for electrogilding; or use an old bath in which a great many copper articles have been gilt, with an intense current of electricity. Yellow gilding may be made to pass to red, by heating it after it has been covered with a paste of copper acetate, cream of tartar, and common salt. Plunge the heated piece into weak sulphuric acid, and carefully scratch-brush afterwards.

(*b*) To 4 oz. melted yellow wax, add 1½ oz. red ochre in fine powder; 1½ oz. verdigris, calcined till it yields no fumes; and ½ oz. calcined borax. It is necessary to calcine the verdigris, or else, by the heat applied in burning the wax, the vinegar becomes so concentrated as to corrode the surface, and make it appear speckled.

Pink.—This kind of gilding is the most difficult to obtain on account of the different tendency of the various metals to metallic decomposition. Pink gilding, to be perfect, should present at the same time the red, yellow, and white shades, in such a manner that a practised eye will distinguish them. The articles are first gilt yellow by the pyrophosphate bath for dipping, or by the hot electro-bath. Then, without drying, but keeping them in fresh water, small packages are made weighing 1–2 oz. each; pass lightly through the mercurial solution, and then red gilt in an old and hot bath, where a great deal of copper has already been gilt, or in a new bath composed of 10 parts hot electrogilding bath, and 3 to 4 parts of the first coppering solution, with battery. For imparting the whitish tint of articles gilt by stirring and of the gold alloy for jewellery, the red gilding is passed through a boiling and nearly exhausted bath of pyrophosphate, to which add $\frac{1}{10}$–$\frac{1}{30}$ of its volume of a silver bath, or simply a few drops of a concentrated solution of silver nitrate. In either case a blush of silver is deposited upon the red gilding. This gilding should be scratch-brushed or burnished, and may be chased, but the lustre soon disappears on account of the proportion of copper. To obtain the proper pink gilding, if the first deposit is unsatisfactory, plunge the articles for a few seconds into a mixture of 5 parts sulphuric to 1 of nitric acid. The copper and silver are dissolved, and the yellow gilding reappears, upon which the operation may be begun anew. Besides the variations of colour in gilding due to the dipping of the anodes more or less into the bath, and to the strength of the electric current, moving the articles about in the bath will at all times enable the operator to vary the colour of the deposit from pale straw yellow to a very dark red. The temperature of the solution likewise influences the colour of the deposit, the colour being lightest when the solution is cold, and gradually becoming darker as the temperature increases.

Yellow.—6 oz. saltpetre, 2 oz. copperas, 1 oz. white vitriol, and 1 oz. alum. If it be wanted redder, a small portion of blue vitriol must be added. These are to be well mixed, and dissolved in water as the colour is wanted.

Dead Lustre Gilding, equal in appearance to the best mercury gilding, is obtained — (*a*) With silver. An electro-silvered bath is prepared by dissolving in 2⅛ gal. water, 5¼ oz. fused silver nitrate, and adding 9 oz. pure potassium cyanide; this at first produces an abundant precipitate, which soon dissolves. The filtered liquid is the silver bath, in which is steeped the zinc article previously coated with copper or brass. Under the influence of a proper electric current, the silver deposited is of a handsome frosted dead lustre appearance, and perfectly white. The object is then rapidly and thoroughly rinsed, and dipped into an electrogilding bath. The dead gilding by this process is very fine and silky, but is soon darkened by the sulphuretted hydrogen of the atmosphere and of gaslight, which sulphurises the silver through the thin film of gold.

(*b*) The galvanoplastic process is both more durable and more economical than that with silver. Add to the necessary quantity of water, $\frac{1}{10}$ its volume of sulphuric acid; in this dissolve as much copper sulphate as it will hold at the ordinary temperature. This solution will mark 20°–24° B., then add enough water to reduce its specific gravity to 16°–18° B. This galvanoplastic bath is generally held in large vessels of stoneware, slate, wood, or gutta percha; and porous shells are immersed in it, filled with a weak solution of sulphuric acid and amalgamating salts. Plates or cylinders of zinc are put into these cells, and are connected by binding-screws with one or more brass rods, which rest upon the sides of the trough, and support the articles which are to receive a dead lustre in this bath. The articles of zinc, previously coated with copper or brass, suspended from the rods, remain in the solution of copper sulphate until they have acquired a satisfactory dead lustre. A few seconds after the articles have been placed in the bath, withdraw and examine them carefully; should the previous coat of copper or brass be insufficient to resist the corroding action of the acid solution of copper sulphate, there is produced a muddy dark deposit, which is easily removed with the finger. Should this occur, the object must be scratch-brushed and placed again in the former alkaline baths of copper or brass, in order to increase the deposit which protects the zinc in the galvanoplastic bath. When the galvanoplastic dead lustre is successful, the deposit is perfectly regular, and of a pink shade which possesses great freshness. When it is irregular, marbled, crystalline, of a vinous or fire-red colour, and dull or earthy in appearance, these defects are due to the following causes: either the bath is in a bad state of conductibility or of saturation; or the surface of the zincs is too large in proportion to that of the objects, and therefore too much electricity is given out; or the previous electro-deposits of copper or brass were insufficient or inferior in quality. The remedy for either of these inconveniences is easily found out, and only requires a little care and attention. The galvanoplastic dead lustre being satisfactory, two preliminary operations are needed to ensure the success of the gilding. They consist in rapidly passing the object, after rinsing, through a solution made of water, 2⅕ gal.; nitrate of mercury, ⅓ oz.; sulphuric acid, ⅔ oz.; then, after rinsing, place it in another solution composed of water, 2⅓ gal.; potassium cyanide, 14 oz.; silver nitrate, 3½ oz. The object acquires a slightly white tinge in this liquor, and is again rinsed in fresh water, before being put into the following gilding bath: Distilled water, 2⅕ gal.; soda phosphate, 21 oz.; soda bisulphite, 3½ oz.; potassium cyanide, pure, ⅓ oz.; gold chloride, neutral, ⅔ oz. The mode of preparation of this bath is given in the recipe for hot gilding bath. This bath should be nearly boiling, and worked with an intense galvanic current. The anode is a platinum wire, which, more or less immersed in the liquor, allows of the regulation of the amount of electricity according to the volume, weight, and surface of the object to be gilt. This gilding requires an energetic electric action at the beginning; this is obtained by steeping the platinum wire deeply in the liquid to have the entire surface of the piece covered instantaneously; as the thickness of the deposit increases, the anode is gradually removed from the bath until it only dips in a little. The gilding by this method has a remarkable freshness of tone. Before using the bath with battery, the zinc articles may be passed through a preparing bath; this is the same as a gold bath for dipping. Or the gilding may be done in two operations. After having deposited about half of the gold intended for the object, remove it from the bath, wash, pass again through the mercurial solution, and replace in the gold bath for finishing the gilding. After gilding, the articles are rinsed in clear boiling water for a few seconds to remove any saline matters; they are then dried in the stove, or in warm sawdust of fir-wood. All friction should be carefully avoided, so as not to scratch the dead lustre. When parts of this gilding are burnished, their colour is green if the frosted surface has been obtained in the silver bath, and red if the galvanoplastic bath has been employed. These inconveniences are remedied by dipping the burnished article, for a short time, into the gold bath; this last deposit of gold must be so thin as not sensibly to impair the brightness of the burnished parts. Dead lustre electrogilding upon zinc will only suit such objects as have no friction to bear, and which are not often handled; it is especially useful for clocks and similar articles, which remain under glass. The dead lustre gilding here described can be applied to all metals and alloys, provided that those corroded by the solution of copper sulphate be previously coated with copper or brass; these previous coatings are always desirable, as they prevent the crystalline and irregular deposits often formed upon metals which are not corroded by the bath of copper sulphate. The galvanoplastic dead lustre upon copper is much finer when the pieces have been previously covered with copper or brass in the alkaline baths. Faded gildings may be renovated by dipping them into a weak tepid solution of potassium cyanide, and afterwards into very dilute nitric or sulphuric acid. Imperfect gildings may be removed by inverting the poles in a solution of cyanides, connecting the gilt articles with the positive pole (carbon or copper), and the negative pole (zinc), with the anode which becomes gilt. This process is employed for removing the gold from articles of iron, steel, and silver, which cannot be submitted to the ungilding bath. Silver, copper, and brass may also be removed by similar processes.

Flowers and Insects.—Christiani's method of preservation of organic bodies coated galvanoplastically is as follows: A mulberry leaf, a crab, a butterfly, a beetle, the brain of a rabbit, a rose-bud, and other objects, were plated with silver, gold, or copper, and showed all details of their outer form, down to the finest shadings. As to the process, it was stated that the objects to be preserved, being put into a solution of silver nitrate in alcohol, then dried and treated with sulphuretted and phosphuretted hydrogen, form good conductors, which, brought in the usual way into the galvanoplastic bath, can be coated with any desired thickness of a metallic deposit.

Glass and Porcelain.—(*a*) Sulphur is dissolved in oil of spike lavender until it has a semi-liquid consistence; this is mixed with an ethereal solution of gold chloride, and the mixture is evaporated to the consistence of paint. The surface to be gilt is then covered with the mixture and the object is carefully heated in a muffle, whereby the volatile substances are expelled, and the metallic gold is fastened upon the glass or porcelain. The surface, thus metallised, is afterwards plated in the usual manner with solution of gold, and with the aid of a galvanic battery.

(*b*) Mix first in a crystal mortar, and then between a muller and a ground plate glass, neutral platinum chloride with rectified essence of lavender, so as to form a thin syrup, which is applied with a brush in very thin layers upon the object. After drying, heat in a muffle up to a dark red; this temperature reduces the platinum to the metallic state; it then appears with a perfect polish. After cooling, pass the whole object through aquafortis, which is without action upon the platinum, but destroys the impurities which may tarnish its surface. Rinse in plenty of water, wrap the object with a few turns of fine brass wire, having numerous points of contact with the platinised places, and dip into the gold bath. After a few minutes, the platinum is covered with gold which has the same adherence and polish. Rub the gold with chamois leather; this method dispenses with burnishing, which is costly, and often impracticable in the deeply indented parts. If the gilding be too red, add to the bath a few drops of a solution of double cyanide of potassium and silver (liquor for silver electroplating). This method is preferable to that of baths with separate battery; the gilding has a bright instead of a dead lustre, and its adherence is greater.

Iron and Steel Deposits.—Iron may be deposited by the wet way, but is very easily oxidised. It is obtained by decomposing by the battery a perfectly neutral iron protochloride. This bath is rapidly altered by the air, and is transformed into sesquichloride, which is unsuited for the purpose. The double chloride of iron and ammonium, obtained by the protracted boiling of a solution of sal-ammoniac upon iron filings, produces a very thin deposit of iron, very difficult to oxidise, which is employed for hardening the surface of engraved plates or of ordinary electrotypes. Double sulphates of iron and ammonia, or of iron and potash, and double chlorides of the same bases have been successfully used for electro deposits of iron.

Lead Deposits. — (*a*) Electrometallurgists do not write in favour of the electro-deposition of lead, viewing it from a commercial point of view. But some persons view the operation with interest, as a means of coating iron with lead to resist the attacks of acid. Following are the results of some experiments with the only promising solution of lead at command, and the course of reasoning which led up to them :—

Reviewing the scanty information obtainable on the subject, and the solutions used by other experimentalists, we were led to abandon all thought of using an acid solution, because the free acid liberated at the cathode would have a tendency to attack both the deposited metal and the metal on which it was deposited, and in this way cause a loose deposit. A similar reason led us to reject a solution of the double cyanide of lead and potassium. Knowing that caustic soda has no action on iron, but will readily dissolve an anode of lead, we decided to use a solution of soda plumbite prepared as follows : Dissolve ¼ lb. best caustic soda in ½ gal. distilled water made to boil in an iron saucepan ; when the caustic alkali is all dissolved, add ½ oz. litharge, and stir well until all the litharge is dissolved. Allow the liquid to cool ; carefully decant it from the saucepan into a stoneware vessel, and add 1 qt. more distilled water, when the solution will be fit for use. The iron to be coated with lead must be freed from rust and scale by filing, and then scouring with sand and water until bright. It must then be put at once into the depositing solution. Attached to the wire leading from the zinc element of the battery, a sheet of lead, slightly larger than the article to receive the deposit, must be suspended in the solution from the wire leading from the copper element of the battery, and care must be taken to have the battery elements, larger in surface exposed to the liquid than that of the lead anode.

Deposition must be allowed to proceed slowly, and it will be found that an E.M.F. of 1 volt, or the current from one Daniell cell alone, will be amply sufficient to decompose the solution, and throw down a reguline adherent coat of lead on the iron.

On raising the E.M.F. to 1½ volt a slightly porous imperfectly-adherent deposit was obtained, whilst 2 volts gave a crystalline non-adherent deposit. The crystals formed with great rapidity on increasing the force of the battery, and quickly resolved themselves into large granular lumps when the force had been raised to 12 volts, whilst at the same time hydrogen was given off in abundance from the anode in a mass of frothy foam. It will thus be seen that the necessary conditions to ensure a reguline deposit of lead upon iron may be obtained from a constant battery of low E.M.F., such as the Daniell, operating on a solution of soda plumbite with an anode of sheet-lead. Should the deposit show a tendency to form in crystals, it will be well to take the articles out of the solution, rinse them in water, and burnish down the crystals with a burnisher of polished steel, after which the articles may be replaced in the solution to receive a thicker coat. A similar operation must be performed when the required coat has been deposited, and thus a smooth surface secured before the lead becomes oxidised.

(*b*) After the soda plumbite bath has cooled off, the metallic or metallised article, connected with the positive pole, is dipped into it. Then the platinum wire, communicating with the negative pole, is gradually introduced into the liquor without touching the article, which is immediately coloured in various shades ; too much intensity in the current will hide all the various tinges under a uniform dark brown coat. When an article is unsatisfactory in its colouration, dip it rapidly into aquafortis, to dissolve the lead oxide, and restore the metallic surface to its primitive state. This process may be used for the decoration of stoneware and porcelain previously coated with platinum.

(*c*) Prof. Emerson Reynolds thus describes one of the best methods of applying his process of galenising, or covering with lead various substances. Take 16 grm. solid sodic hydrate (NaOH), dissolve it in 1·75 litre water, and add to the liquid 17 grm. lead nitrate $(\mathrm{Pb2NO_3})$ with 250 c.c. water ; raise the temperature of the mixture to 194° F. If sufficient lead salt has been added, the liquid will remain somewhat turbid after heating, and must then be rapidly strained or filtered through asbestos or glass-wool, into a convenient vessel. The filtered liquid is then well mixed with 100 c.c. hot water containing in solution 4 grm. sulpho-urea or thio-carbamide. If the temperature of the mixture be maintained at about 168° F., deposition of galena in the form of a fine adherent film or layer quickly takes place on any subject immersed in or covered with the liquid, provided the object be in a perfectly clean condition and suitable for the purpose. When the operation is properly conducted, a layer of galena is obtained, which is so strongly adherent that it can be easily polished by means of the usual leather polisher. It is not necessary to deposit the galena from hot liquids, but the deposition is more rapid than from cold solutions.

The most convenient solution for deposition on brass is thus prepared. Take a quantity of soda lye containing 1½ oz. real soda (NaOH); dissolve in this, with the aid of heat, 3 oz. lead tartrate, and just before diluting the solution to 1 gal. cold water, add 5 dr. sulpho-urea previously dissolved in a small quantity of hot water. The articles are to be immediately immersed in this bath, and the temperature raised to boiling. When the desired tint is obtained, the articles are to be removed, washed, and polished. The above solution can be used for glass or porcelain, hot or cold, if the proportion of alkali be reduced one-third or thereabouts.

Nickel.—(*a*) The plant necessary to commence nickel plating consists of a battery, preferably of the Smee type with carbon negative; a well-bolted oblong wooden tank, of a size to suit the articles to be plated, coated on the inside with good asphalt, and nearly filled with the nickel solution; nickel plates for anodes, and brass rods to suspend the plates and work in the bath; suitable vessels for an alkali, an acid, and soft water for cleaning the work before placing it in the nickel bath; polishing and buffing lathes, rouge, crocus, etc. The bath may be composed either of nickel chloride and ammonia or the corresponding sulphate, dissolved in pure water. If the latter is used, the solution must be kept neutral and up to about 6°. It is prepared by dissolving ¾ lb. of the salt in each gallon of water. This salt is generally considered the best for nickel plating. The chloride bath requires about 4 oz. of the salt per gallon, and works better with a slight acid reaction, the tendency in working being towards alkalinity, even with great exposure of anode. The intensity of battery current must be proportioned to the bath, and remain constant. Large baths offer less resistance to the electric current than those of smaller dimensions, and can therefore be worked with a current of somewhat less tension. For a bath of 10 gal. or less, the tension of the current should be equal to that of 2–3 Smee cells (carbon and zinc) in series. The exposed surfaces of the nickel anodes should in no case be less than the surface to be coated, but may with advantage be greater. The amount of battery power for a given amount of work should be in zinc surface equal to the surface to be coated, with care to preserve the normal tension of the current. If the current is too intense the coating will present a dull white or frosted appearance. The anodes must be in connection with the negative plate (carbon) of the battery. Damage is not unfrequently done to the bath and work by misconnection. The work should be scrupulously clean when entered to the bath, and should be carefully moved about after entering to free it from any adhering air-bubbles. If the finished work is to have a smooth polishing surface it must present such a surface before entering the bath. Nickel is hard and cannot well be burnished. Traces of oil and grease are removed by a hot soda solution. After dipping in clean water the surface is freed from films of oxide by an acid bath. If the work is of iron the acid may be hydrochloric diluted with 3–4 volumes of water; if of copper or brass, of nitric acid diluted with about 20 parts water. Brighten the work in the acid dip, then immerse momentarily in water; go over it with a clean stiff brush and very fine sand; again dip in the acid, then quickly in soft water, and place immediately in circuit. The hand must not come in contact with the surface of the work after removal from the alkali, as the slightest touch may spoil all. On removal of the work from the plating bath it should be immediately dipped in cold water and transferred to hot water, which will cause it, when taken out, to dry quickly and perfectly. The bath should be covered when not in use, to keep out dust and prevent as much as possible its evaporation.

By a little practice and proper attention to these simple rules the nickel bath may be worked continuously, month after month, and the metal deposited smoothly and with certainty.

(*b*) Complaint is often heard against white nickeling not succeeding. This may be due to the current, that is too weak or too strong, or to the composition of the bath, but frequently the cause is to be sought in the nickel film being too thin, so that the metal beneath, which is generally brass, shows through. In the case of iron this is not so striking, owing to the similarity in the colour of iron and nickel. But here there is another disadvantage of thin nickeling, that the iron rusts. There is always danger of rusting, even when well plated, if the iron has been cleansed in acid. This evil may be entirely overcome by using the sand blast instead of acid pickle. Another advantage gained is that the surface is roughened and the nickel adheres to it better, while subsequent polishing is unnecessary.

Experience has shown that scythes cannot be put in pickle before nickeling as they soon become checked or cracked in the bath. Some scythes were polished with sand blast, and then nickel plated with entire success. This would seem to solve the problem of how to best protect scythes from rust, for the innumerable experiments and attempts to protect them with varnishes have always given negative results.

One difficulty often met with in nickel plating brass and zinc should not go unmentioned. These and other metals which are flexible yet only slightly elastic, do not quite return to their original shape after the bending force has been removed, while nickel is so elastic that it endeavours to return to its former position.

This is frequently the cause of nickel plate getting loose when deposited on these metals. A thin layer of nickel sticks better, but, as already mentioned does not prevent the other metal from showing through, while it offers little or no protection against oxidation.

(*c*) There is a general opinion that nickel plating direct on iron is not a success for every purpose. For the bright parts of cooking-stoves and fireplaces that get at all hot, it is found best—necessary in fact—to first put a deposit of copper on the iron. After the articles come out of the coppering bath (where they should receive only the merest film of copper) they should be immediately rinsed in water and plunged directly into the nickeling bath, which is made by dissolving 12 oz. of ammonia sulphate of nickel in one gallon of water. Cast nickel anodes should be used. At the start, the current should be supplied at about 8 volts pressure, but as soon as a film has been deposited it should be diminished to 6 volts.

(*d*) By the process used at Mons, in Belgium, a thick plating of nickel may be deposited upon any metal by a feeble electric current in a very short space of time. The composition of the bath is as follows : Nickel sulphate, 1 kilo.; neutral ammonia tartrate, ·725 kilo.; tannic acid, ·005 kilo.; water, 20 litres. The neutral ammonia tartrate is obtained by saturating a solution of tartaric acid by ammonia. In the same manner the nickel sulphate must be exactly neutralised. Three or four litres of water are at first added, and the solution is made to boil about ¼ hour. The rest of the water is then added, and the liquid is filtered or decanted. This bath may be renewed indefinitely by adding the same materials and in the same proportions. The deposit obtained is brilliantly white, soft, and homogeneous. Even when obtained of great thickness there are no irregularities on the surface, and it has no tendency to scale. Some very thick deposits of nickel upon both rough and polished cast-iron goods have been obtained by this process at a cost scarcely exceeding that of copper.

(*e*) For the baths, Gaiffe gives the following formula :—

Nickel and ammonia, double sulphate	1 kilo.
Distilled water	10 litres.

Roseleur prefers to take :—

Double sulphate . . .	400 grm.
Ammonium carbonate . .	300 grm.
Distilled water	10 litres.

Each of the two salts is dissolved separately in a part of the water. The solution of ammonium carbonate is gradually poured into that of nickel, taking care not to pass the point of neutrality. The quantity of 300 grm. ammonium carbonate indicated above is not obligatory, but may be varied according to the quality of the salt of nickel.

(*f*) Adams proposes the two following mixtures :—

Chloride. — Take 135 grm. pure nickel, and dissolve in hydrochloric acid, avoiding excess, and heating gently. When all is dissolved, add 2·25 litres cold water, and add gradually ammonia until the liquid is neutral to litmus paper. Dissolve separately 70 grm. sal-ammoniac in water, and mix with the former solution, and make up to 10 litres with cold water.

Sulphate.—Dissolve 135 grm. pure nickel in sulphuric acid diluted with twice its weight of water, and heat until the metal is dissolved. Add water and neutralise with ammonia. Dissolve separately 70 grm. ammonium carbonate, and neutralise the solution carefully with sulphuric acid. Add this liquid to the nickel sulphate, and make up to 10 litres with cold water. In both cases filter the liquids or dilute after standing. Adams ascribes a good deposit of nickel to the absence of potassa or soda, while in reality excellent deposits may be obtained in ammoniacal baths containing salts of potassium or sodium.

(*g*) *Weston's Solution.*—5 parts double sulphate of nickel and ammonium, 1½ to 2½ parts refined boric acid, 75 to 100 parts water. Dissolve the salt and acid separately in boiling water, then mix.

(*h*) *Pott's Solution.*—2¾ parts acetate of nickel, 2½ parts acetate of calcium, 100 parts water. To each gallon add 1 oz. acetic acid 1·047 specific gravity.

(*i*) *Simple Bath.*—4 to 5 parts by weight of pure double sulphate of nickel and ammonium to 50 parts distilled water. If too acid neutralise slightly with spirits of sal-ammoniac. To prepare the solution boil the nickel salt in the water. In warm weather use 5 parts nickel, in cold weather 4 parts. A strong current is required and a cast nickel anode.

To give the goods a fine polish after nickeling the treatment is the same. Lime paste may be used for removing grease in the usual manner, but this must be done on a soft support as in polishing. Give a thorough rinsing in clean water, then take the pieces, without being coppered, and put directly into the nickel bath, this being, of course, suitable for steel goods. The best plan is to give a strong current at first and then continue and finish with a weak current. This gives the most uniform coat.

A neglect that often occurs, with bad results, is that of suspending keen edged instruments with the edges (or points) towards the anode. This should not be done ; consequently, it is best to use a bath with anodes at one side only. If the blades must come between anodes then let the edges be uppermost, not downwards, nor hanging deep way.

(*j*) Large plates have been known to disintegrate and fall to pieces after being used for some time. A large anode surface, compared with that of the article to be plated, is of paramount importance. The tank should be sufficiently wide to take the largest article for plating, and to admit of the anodes being moved nearer to or farther from the article. In this way the necessary electrical resistance can very conveniently be inserted between the anode and cathode surfaces. The elimination of hydrogen from the cathode must be avoided, or at any rate must not accumulate. Moving the article being plated, while in the bath, taking care not to break the electrical contacts, is a good security against a streaky or foggy appearance in the deposit.

At one time a mechanical arrangement was made, by which the cathodes were kept in motion. The addition of a little borax to the bath is a great advantage in mitigating the appearance of gas. Its behaviour is electrical rather than chemical. If the anode surface is too great, a few plates should be transferred to the cathode bars.

When an article has been nickel plated, it generally presents a dull appearance, resembling frosted silver. To get over this I tried, some time ago, the use of carbon bisulphide in the same way as used for obtaining a bright silver deposit. Curiously the deposit was very dark, almost black, which could not be buffed or polished bright. But by using a very small quantity of the bisulphide mixture, the plated surfaces were so bright that the use of polishing mops or buffs could be almost dispensed with. When we consider the amount of labour required in polishing a nickel plated article, and the impossibility of finishing off bright an undercut surface, this becomes an important addendum to the nickel plater's list of odds and ends.

This mixture is made precisely in the same way as for bright silvering, but a great deal less is to be added to the bath, about 1 pint per 100 gal. It should be well stirred in, after the day's work is done, when the bath will be in proper condition for working next day. The mixture is made by shaking together, in a glass bottle, 1 oz. bisulphide, and 1 gal. of the plating liquid; allow to stand until excess of bisulphide has settled, and decant the clear liquid for use as required. It is better to add this by degrees than to run the risk of overdoing. If too much is added, the bath is not of necessity spoiled, but it takes a great deal of working to bring it in order again.

About 8 oz. of the double sulphate to each gallon of distilled or rain water is a good proportion to use when making up a bath. There is a slight excess with this. It is a mistake to add the salt afterwards, when the bath is in good condition. The chloride and cyanide are said to give good results. I can only say that the use of either of these salts has not led to promising results in my hands.

In preparing the double sulphate, English grain nickel is decidedly the best form of metal to use. In practice, old anodes are generally used.

The metal is dissolved in a mixture of nitric and dilute sulphuric acid, with the application of a gentle heat. When sufficient metal has been dissolved, and the unused nitric acid expelled, the salt may be precipitated by a strong solution of ammonia sulphate, or, if much free acid is present, ammonia carbonate is better.

Tin, lead, and a portion of the iron, if present, are removed by this method. The silica, carbon, and portions of copper are left behind with the undissolved fragments of metals.

The precipitated salt, after slight washing, is dissolved in water, and strong solution of ammonia is added. A clean iron plate is immersed in the solution to remove any trace of copper. This plate must be cleaned occasionally so as to remove any reduced copper, which will impede its action. As soon as the liquid is free from copper, it is left alkaline, and well stirred so as to facilitate peroxidation and removal of iron, which forms a film on the bath. When this ceases, the liquid is rendered neutral by addition of sulphuric acid, and filtered or decanted. The solution, when properly diluted, has sp. gr. about 1·06 at 60° F. It is best to work the bath with a weak current for a short time until the liquid yields a fine white deposit. Too strong a current must be avoided.

If the copper has not been removed, it will deposit on the anodes when the bath is at rest. It should then be removed by scouring.

Copper produces a reddish tinge, which is by no means unpleasant compared with the dazzling whiteness of the nickel deposit. If this is desired, it is far better to use a separate bath, with anodes of suitable composition.

The want of adhesion between the deposited coating and the article need not be feared if cleanliness be attended to and the article, while in the bath, be not touched by the hands.

The bath should be neutral, or nearly so, slightly acid rather than alkaline. It is obvious that, as such a liquid has no detergent action on the soiled surface, scrupulous care must be taken in scouring and rinsing. Boiling alkaline solutions and a free use of powdered pumice and the scrubbing brush must on no account be neglected.

A few words on the construction of the tanks. A stout wood box, which need not be watertight, is lined with sheet lead, the joints being blown, *not soldered*. An inner casing of wood which projects a few inches above the lead lining is necessary to avoid any chance of "short circuiting" or damage to the lead from the accidental falling of anodes or any article which might cut the lead. It is by no means a necessity that the lining should be such as to prevent the liquid getting to the lead. (T. Bruce Warren.)

(*k*) Nickel plates and sheet nickel may be used in the production of a solution which is particularly well adapted for nickel plating. To this end the nickel is placed on a perforated board in a saturated solution of ammonium chloride (sal-ammoniac), and the metal is brought into connection with the positive pole of a strong battery. By the influence of the electric current the metal gradually becomes dissolved, and a double salt is formed (nickel ammonium chloride), which settles on the bottom of the vessel, while, at the same time, the metal is kept continually in contact with the ammonium chloride.

If the nickel has previously been weighed, the amount of the metal which has become dissolved can at any time be determined by weighing the as yet uncombined nickel. In order to nickelise with this solution, a plate of pure nickel is suspended in the fluid, and it is connected with the positive pole of the battery, while the metallic body which is to be coated, and which must, of course, be well cleaned, is connected, after it has been immersed, with the negative pole. The nickel is precipitated from the solution as a bright coat, whose thickness depends upon the length of time during which the current is acting upon it, and also upon the strength of the latter.

In order to operate directly with the nickel sulphate, it is necessary to have a salt entirely acid free, which may readily be prepared by adding a small quantity of sodium hydrate (caustic soda) to the solution of the commercial salt, after having first removed the copper in the manner which will presently be described. When the acid is neutralised, an apple-green precipitate of nickel hydrate is formed, which is boiled for some time and then filtered. The solution is now perfectly neutral.

To remove the copper from the nickel salt, the latter is first dissolved in water and acidulated by a few drops of sulphuric acid (commercial nickel sulphate is generally acid), then a current of hydrogen sulphide gas, which is prepared by pouring sulphuric acid over iron sulphide in a flask, is passed through the solution.

The copper and other metals which are likely to be present are thrown down in the form of a black precipitate. When the odour of the gas is distinctly recognised, its passage is stopped, and the solution is heated to expel the last traces of the hydrogen sulphide. It is then heated to boiling in a porcelain vessel with the addition of some metallic nickel. By this means the free acid is neutralised, and on evaporating to crystallisation there remains a salt sufficiently pure for nickel plating.

The articles which are to be plated are suspended in the solution which we have just described, and they are connected with the positive pole. A nickel plate, which also dips into the liquid, is connected with the negative pole ; and from time to time the liberated acid is neutralised by the addition of a slight quantity of ammonium hydrate. It is better still, for practical results, to spread a layer of nickel oxide over the bottom of the vessel in which the nickelising is being carried on. This will dissolve in the free acid, and the solution will therefore remain neutral and of uniform strength.

The nickel oxide is prepared by completely saturating a solution of nickel sulphate with sodium hydrate (caustic soda), washing the precipitate, and then drying it. The nickel oxide thus formed is a heavy powder of an apple-green colour, and may be either spread over the bottom of the vessel, or it can be placed in a linen bag and suspended in the liquid. If a solution of nickel sulphate, acidified with sulphuric acid, is poured into a saturated solution of ammonium sulphate, crystals will separate out, consisting of the double salt of nickel ammonium sulphate. The crystals are washed with cold water, dissolved in hot water, and then the solution is completely neutralised with ammonium hydrate. It is then allowed to stand for several days at a temperature of 68°–77° F., until no more crystals separate out. It is also of importance that the liquid be maintained at this temperature during the nickelising, for otherwise the nickel will not adhere firmly to the metal.

During the operation of plating, a sheet of nickel, connected with the positive pole of the battery, is suspended in the solution. According as the nickel becomes separated from the solution the sheet dissolves, and thus the solution maintains its original strength. Plates of absolutely pure nickel are at present quite expensive, in consequence of the very high temperature which is required for their fusing and casting. By the addition of $\frac{1}{1000}$th part of phosphorus its point of fusion may be considerably lowered. As the phosphorus is not objectionable in nickelising, the plates are generally made of metal containing phosphorus, and they are used to the best advantage in rather thin sheets, for, the larger the surface of the nickel plate, the less will be the strength of the current required ; and when the pieces to be plated are not large, as will occur in the majority of cases, two or three Bunsen elements will be sufficient.

In addition to the above methods for nickel plating, others have been proposed which also give good results, but which require more expensive preparations than those previously mentioned ; thus, for instance, the double salt of nickel potassium cyanide and solutions of nickel nitrate have been proposed. On account of the vapours which escape from the cyanide solutions, although only in small quantities, they are particularly objectionable, and therefore the employment of cyanide preparations, on account of their poisonous properties, should be avoided whenever it is possible to do so. The nickel nitrate gives a beautiful and durable coat of nickel. The solution is most effective when it is composed of 4 parts crystallised nickel nitrate dissolved in 150 parts water, to which 4 parts ammonium hydrate are added, and then 50 parts of acid sodium sulphite are dissolved in the above solution.

The acid sodium sulphite is prepared by heating copper with sulphuric acid in a retort ; the gas produced is passed through a small quantity of water, which will retain the copper which has been mechanically carried over, and then the gas (sulphurous acid) is dissolved in water until the liquid smells distinctly of burning sulphur. The solution which has thus been obtained is divided into two portions: one part is saturated with sodium carbonate as long as effervescence takes place, the other half of the acid is then added, and in this manner sodium bisulphite is produced. This must be employed as it is, because it is impossible to crystallise the salt by evaporation, for in so doing one half of the acid would escape, and sodium mono-sulphite remain behind.

For nickel plating of the finest kind, such as is produced in American factories, a solution is prepared from the nickel nitrate and acid sodium sulphite. It sometimes happens that the nickel will strip or peel off from the metals on which it has been deposited. It is said that this objection can be overcome by placing the dried plated objects in a bath of oil and heating them up to 482°–518° F.

(*l*) According to Weston, a plating of great beauty and durability is obtained by mixing a solution composed of 5 parts nickel chloride and 2 parts boracic acid with one made up of 2 parts nickel sulphate and 1 part boracic acid, and then adding, while continually stirring, sodium hydrate (caustic soda) until the precipitate is redissolved.

Palladium Deposits. — Palladium has of recent years been much used to plate watch movements. According to Pilet, 4 mgrm. palladium are sufficient to coat the works of an ordinary sized watch. Pilet recommends the following bath: Water, 2 litres; palladium chloride, 10 grm.; ammonia phosphate, 100 grm.; soda phosphate, 500 grm.; benzoic acid, 5 grm. This bath is suitable for all metals except zinc.

Platinum Deposits.—(*a*) Copper and its alloys only will receive a satisfactory platinum deposit; iron, zinc, lead, or tin, coated with this metal, even after a previous coppering, give but defective results. The platinum deposits are obtained by dipping thoroughly cleansed copper articles in the following solution, kept boiling: Distilled water, 100 parts by weight; caustic soda, 12; platinum for neutral chloride, 1. The deposit is bright, durable, and of a dark colour, resembling oxidised silver.

(*b*) The platinum baths for electro-deposits will succeed when platinum chloride is dissolved in a solution of a salt with alkaline, neutral, or acid reaction, but sulphites and cyanides, even those having soda for base, should be excepted. Distilled water, 100 parts by weight; soda carbonate, 40; platinum for neutral chloride, 1. Temperature of the bath, 160°–180° F. Distilled water, 100 parts by weight; soda phosphate or borate, 60; platinum for neutral chloride, 1. Distilled water, 100 parts by weight; soda pyrophosphate, or chloride or iodide, 30; platinum for dry chloride, 1. These baths only give exceedingly thin deposits; if the coating were allowed to increase most of it would be without adherence, and often in the form of scales. The deposit is black or steel grey.

(*c*) Fill a glass flask with ½ oz. finely-laminated spongy or black platinum, and a mixture of 5½ oz. hydrochloric acid and 3½ oz. nitric acid at 40° B. Place the flask upon a piece of sheet iron perforated in the centre, so that the bottom of the flask alone receives the heat. After an abundant production of orange-yellow fumes, the platinum will disappear and leave a red liquid, which should be heated until it becomes viscous enough to stick against the sides of the flask. This latter part of the operation may be effected in a porcelain dish, the shallow form of which aids in the evaporation of the acids in excess. After cooling, the residuum is dissolved in 17½ oz. distilled water, and filtered if necessary. Dissolve 3½ oz. ammonia phosphate in 17½ oz. distilled water, and mix the two solutions. This produces a precipitate of ammonia and platinum phosphate in a liquid of orange colour, which should not be separated; pour into it, stirring all the while, another solution of 17½ oz. soda phosphate in 1¾ pint distilled water. Boil the mixture, and replace the evaporated water, until no more ammonia is disengaged, which is ascertained by the smell; and until the liquor, which was previously alkaline, begins to redden blue litmus paper. When the yellow liquor becomes colourless, it indicates the formation of a double platinum salt. The bath is then ready to deposit platinum upon articles of copper or its alloys. by the aid of heat and of an intense electric current. Copper coated with platinum resists nitric and sulphuric acids to a considerable extent. If iron, zinc, lead, or tin come in contact with the bath they will decompose it, and the metal deposited will be black. The dead lustre of platinum is pearl-grey; it is very hard, and cannot be brightened by scratch-brushes of brass, which render its surface yellow; powdered pumice or iron wires should be employed. Platinum deposits may be burnished by an energetic friction, and the lustre obtained is very durable. Platinum may be removed from copper by a very long immersion in the liquors given for ungilding, but the success is doubtful.

Silver.—*Small Bath for Amateurs.* The bath is a cylindrical stoneware, glass, or porcelain vessel. After cleansing and amalgamation, the articles are attached by clean copper wires to the circumference of a brass ring, supported upon the top of the apparatus by 3 or 4 soldered cross wires. The ring is connected with the negative pole of the battery, and the positive pole with a platinum anode, or a cylinder formed of a sheet of silver rolled round, which dips into the middle of the apparatus. The articles must be now and then turned upside down, and sideways, so that each face of the object will be, in turn, directly opposite the silver anode, and thus also the points of contact with the suspending wires receive their quota of metallic deposit. Points, edges, corners and all raised parts, offer a more easy passage to the electric current, and therefore become more coated with metal. As the wear of tablespoons and forks is greater on their convex sides, those parts should face the silver anode longer than the concave portions.

Ascertaining Weight of Silver Deposited.—(*a*) The articles are cleansed, dried, and weighed in a scale. However rapidly this may be done, the surface of the copper will be slightly oxidised and tarnished; to recover their former cleanliness, the articles must be plunged into a strong pickle of sulphuric acid, and then into the mercurial solution. After rinsing, and immersion in the bath, practical experience will teach when it is nearly time to withdraw the articles from the solution. They will have to be weighed several times before the intended weight of silver has been deposited.

(*b*) Cleanse the articles, and put them immediately into the bath, except one, which is treated as above, and used as a test. This piece is now and then removed from the bath to ascertain its increase of weight, and when it has acquired its proportion of silver, it is supposed that the other pieces are also finished. Strongly amalgamated articles will not become sensibly oxidised during the drying, which precedes their weighing. When the objects have been dried in order to ascertain the proportion of deposited silver, they should not be returned to the bath without having been cleaned in a hot solution of potash cyanide, which dissolves the grease from the handling, and passed again through the solution of nitrate of mercury, and rinsed. Alcohol may be substituted for the hot solution of cyanide, but the results are not so sure, and the expense is greater. Both these methods are tedious, and only give approximate results.

(*c*) Remove one dish of an ordinary pair of scales, substitute for it a metallic frame which supports the articles to be silvered, and communicates through the beam and the column with the negative electrode of a battery; connect the soluble anode with the positive pole. When the articles are suspended to the frame, and are in the bath, the equilibrium of the scale is established by weights upon the other dish ; add to this a weight equal to the silver it is desired to deposit. The operation will be finished when the equilibrium of the beam is re-established. This method is not mathematically accurate, but is sufficiently exact for all practical purposes. An automatic arrangement, by which the electric current may be broken at the time the articles in the bath have received a sufficient deposit of silver, is easily arranged, and saves time and metal.

Electroplating Baths.—Water, 2⅕ gal. ; potassium cyanide, pure, 17½ oz. ; pure silver for cyanide, 8¾ oz. The composition of commercial potassium cyanide is exceedingly irregular. The pure, or No. 1, contains 90–100 per cent. real cyanide, and is especially employed for gilding and silvering baths. No. 2 contains 60–70 per cent. real cyanide ; it is the article prepared by Liebig's method, and is used for electro-baths of copper and brass. No. 3, which marks 55–60 per cent., is for scouring and preparing baths, and for photographic operations. (*a*) Put in a porcelain dish, holding a quart, pure granulated silver, 8¾ oz. ; pure nitric acid at 40° B., 17½ oz. Heat by charcoal or gas. The dish should be supported by an iron triangle, and not in direct contact with the fire. The acid rapidly attacks and dissolves the silver, with an abundant production of yellow nitrous vapours, which must not be inhaled. When the vapours have disappeared, there remains a liquid more or less colourless. according to the proportion of copper held by the commercial silver, which is seldom entirely pure. The heat is then increased in order to evaporate the excess of acid, which escapes in white fumes. The material in the dish swells up and dries, and, with a further increase of heat, melts like wax. The dish is then removed from the fire, and being held with a cloth, the molten mass is made to flow upon the sides, where it soon solidifies ; the fused silver nitrate (lunar caustic) is more or less white, or grey, according to the purity of the silver employed. When perfectly cold, turn the dish upside down, and by a gentle tap on the sides, the mass is detached.

Dissolve the silver nitrate in 10–15 times its weight of distilled water ; hydrocyanic acid poured into this solution immediately produces an abundant white precipitate of silver cyanide. A sufficient quantity of prussic acid has been employed when, by adding a few drops of it to the clear liquid, no precipitate or turbidity appears. Throw the liquid upon a filter of calico stretched on a wooden frame : the silver cyanide remains on the cloth, the solution with the nitric acid and excess of prussic acid passes through. Wash the precipitate left upon the filter two or three times with pure water.

The silver cyanide is put into the vessel intended for the bath, and stirred with the 2⅕ gal. water. The potassium cyanide is then added, dissolves it, and also dissolves the silver cyanide, thus giving a solution of a double potassium and silver cyanide. Those who employ small baths, often renovated, may substitute for the silver cyanide the chloride or the nitrate of this metal. In the latter case, the quantity of potassium cyanide should be increased. Such baths will be prepared as follows :—

The silver nitrate is prepared in the manner indicated above, and 5¼ oz. of it, nearly equal to 3½ oz. pure silver, are dissolved in 2⅕ gal. water.

The potassium cyanide No. 1, about 8¾ oz., is then added. Stir to facilitate the solution, filter the liquor, to separate the iron contained in the cyanide. This operation may in some cases be dispensed with, because the iron rapidly falls to the bottom of the bath, and the solution becomes limpid. The proportion of potassium cyanide employed is more than is required for dissolving the silver, as 1½ part good cyanide is sufficient for 1 part silver; but unless there is an excess of potassium cyanide, the liquors do not conduct electricity well, and the deposit of silver is granulated and irregular. The silvering is effected with a battery, and with baths either warm or cold. The latter method is generally adopted for articles which require great solidity. The hot process is used for small articles, and is preferable for steel, iron, zinc, lead and tin which have been previously electro-coppered. The hot baths are generally kept in enamelled cast-iron kettles, and the articles are either suspended, or moved constantly about in them. The preliminary cleansing in acids, and passing through the mercurial solution are necessary. A somewhat energetic current is needed, especially when the articles are moved about, in order to operate rapidly. There is too much electricity when the articles connected with the negative pole of the battery become grey or black, and produce many bubbles of gas. A platinum large wire or thin foil anode, is generally preferred to the soluble anode of silver employed in cold baths, but the solution is rapidly impoverished. In hot silvering baths, the separate battery is often replaced by a zinc wire wrapped around the articles. The points of contact in the two metals are black or grey, but the stain disappears by plunging the object into the liquor for a few moments, after it has been separated from the zinc, and carefully scratch-brushed. Instead of separate batteries, a simple apparatus may be made of a glass, porcelain, or stoneware vessel holding the bath, and in the centre of which is a porous jar filled with a solution of 10 per cent. potassium cyanide or common salt. The zinc cylinder, immersed in this porous jar, carries a larger circle of brass wire, the cross diameters of which are soldered to the zinc. This brass ring projects over the bath, and the articles, suspended to the ring by slinging wires, hang down into the bath. At the beginning, the operation goes on rapidly, and the deposit is good; but, after a time, the solution of zinc traverses the porous cell and impairs the purity of the bath. An impoverished hot bath is reinvigorated by additions of equal parts potassium cyanide and silver salt. It is necessary to replace the water in proportion as it is evaporated. When the silver baths rapidly deposit metal without the aid of electricity, it is a proof that they are too rich in cyanide, or too poor in silver. A deposit effected under such conditions is rarely adhering, especially when upon articles previously coppered, because the excess of cyanide dissolves the deposited copper, and the silver which takes its place may be removed with the finger. The remedy consists in adding to the bath only enough silver salt and no more, so that a piece of copper will not become sensibly silvered in it, without the aid of electricity. The cold electro-silvering baths generally employed for electroplating such articles as table-spoons or forks are contained in large rectangular wooden troughs lined with gutta-percha, or made of riveted wrought iron. They are sufficiently high to allow about 4 in. of liquid above the immersed object, whose distance from the bottom and sides should be nearly the same, to give a regular deposit of metal at both extremities of the object. The upper ledge of the trough carries two brass rods all round, which do not touch one another, one above the other, so that other metallic rods, being put across, will rest upon the higher or the lower rod, but not on both at the same time. Each rod is connected with one of the poles of the battery by conducting wires, the points of contact of which should be perfectly clean. The rod which supports the articles to be silvered is connected with the negative pole represented by zinc in most batteries; and the other, supporting the anodes, is attached to the positive pole, which is carbon with Bunsen's elements, copper for Daniell's, and platinum with Grove's cells. A certain number of spoons and forks fixed to a rod, by means of copper wires, are cleansed at the same time, and the rod is placed upon the negative conducting rod of the trough. Then, facing these articles, hang upon the positive conducting wire of the trough another metallic rod to which the soluble silver anode is attached like a flag. Next comes another series of spoons and forks, faced by another soluble anode, in such a manner that each row of spoons and forks is between two anodes. The articles to be silvered all rest upon the negative conducting rod, and the soluble anodes upon the positive one. This disposition is for obtaining an equal deposit upon all the pieces. The objects require turning upside down during the operation, in order to prevent a thicker deposit on the lower parts, as the richest part of the solution is the densest, and therefore lies near the bottom of the trough. The denser layers, being richer in metal, deposit it more abundantly upon the direction which they follow, and form grooves which cannot be filled by the lighter and poorer currents. It is, therefore, advantageous to keep the objects in constant motion. In this case the frame supporting the articles does not rest upon the trough, but is suspended above the bath, and receives its motion from a small eccentric, or other motive power. The silver deposit will adhere strongly if the articles have been fully amalgamated in the solution of nitrate of mercury, and have remained in the bath 12–15 hours, according to the intensity of the current. The silvering will be the better and finer as the intensity of the current is weaker, up to a certain limit. A sufficient quantity of silver may be deposited in 3–4 hours, but the result is not satisfactory, and the burnishing is very difficult. When the articles have acquired a film of silver, they are sometimes removed from the bath and thoroughly scratch-brushed, cleansed in alcohol, or, preferably, in a hot silvering bath, thence again passed through the mercurial solution, and finished in the former cold electro-bath. This first scratch-brushing, which is not always necessary, obviates the tendency of certain alloys to assume a crystalline appearance, and corrects imperfections of the cleansing process. Electro-silvering baths do not generally work so well when freshly prepared as when they have been used for a certain time; the deposit is often granulated, bluish, or yellowish. It is therefore desirable to mix a portion of old liquors with those recently prepared, or new baths may acquire an artificial age by boiling them for a few hours, or adding to them one or two thousandths of aqua ammonia.

Resists and Reserves.—By reserves certain parts of a metallic article, which may be already covered with an electro-deposit on its whole surface, are coated with another metal. To gild the parts in relief of an object of which the body is silvered, make a gold reserve, and use a silver reserve for silvering of certain parts of a body already gilt. This requires a little practice and care, and a firm hand to make thin lines with the hair pencil. Thoroughly scratch-brush and wipe the object; the parts intended to have the primitive colour must be covered by a brush with resist varnish: dry in the air, or in a stove, or upon a gentle fire until it no longer feels sticky. Place in the bath; the galvanic deposit will only coat those parts unprotected by the varnish. The temperature of the bath should be low and the current weak, for fear of having rough lines where the deposit touches the varnish, from the latter becoming softened, or from bubbles which are disengaged at the negative pole under the action of a strong electric current. When the deposit is completed remove the resist varnish with warm essence of turpentine, and afterwards with tepid alcohol; gaseline or benzole are preferable as they rapidly dissolve in the cold nearly all resinous and fatty bodies, or the varnish may be destroyed by a brief immersion in concentrated sulphuric acid when cold. It often happens that several colours and metals have to be placed upon the same object such as silver with both a bright and a dead lustre, and yellow, green, red, white, or pink golds, or platinum. Varnishes are also employed for avoiding the deposit of the precious metals upon those parts which do not need them.

Resist or Reserve Varnishes.—Dissolve in boiled linseed-oil or essence of turpentine, rosin or copal; if these varnishes are not sufficiently coloured to distinguish the places where they have been laid on, mix with them therefore a certain proportion of red-lead, chrome yellow, or prussian blue, which at the same time facilitates their drying.

Anodes.—Should the anodes become black during the passage of the electric current, the solution contains too little potassium cyanide and too much silver. In this case the deposit is adherent, but too slow, and the bath loses more silver than it can gain from the anodes. Carefully add sufficient potassium cyanide. If the anodes remain white during the current the proportion of potassium cyanide is too great, the deposited silver is often without adherence, and the anodes lose more metal than is deposited; add silver salt until it dissolves with difficulty. When in good working order, the soluble anodes become grey during the passage of the electricity, and white when the circuit is broken. The specific gravity of the bath may vary from 5° to 15° B. for salts, and still furnish good results. There is a simple and rapid process for ascertaining the state of the bath, and establishing the proper ratio between the silver and the cyanide. About ½ pint of the liquor is put into a tall glass, and a solution of ⅓ oz. silver nitrate in 3 oz. distilled water is poured into the former, drop by drop. If the white precipitate produced is rapidly dissolved by stirring, the liquor is too rich in cyanide, or too poor in silver; should the precipitate remain undissolved after long stirring, the liquor is too rich in silver and too poor in potassium cyanide. When the precipitate is dissolved but slowly, the liquor is in the best condition.

Frosted Silver.—Dip the article in a solution of nitric acid and water, half and half, for a few minutes, then wash well in clean water, and dry in hot sawdust. When thoroughly dry, brush the sawdust away with a soft brush, and burnish the parts required to be bright.

Bright Lustre.—Carbon bisulphide, in small proportion, imparts a bright lustre to electroplated articles. Put 1 oz. carbon bisulphide into a pint bottle containing a strong silver solution with cyanide in excess. The bottle should be repeatedly shaken, and the mixture is ready for use in a few days. A few drops of this solution may be poured into the plating bath occasionally, until the work appears sufficiently bright. The bisulphide solution, however, must be added with care, for an excess is apt to spoil the solution. In plating surfaces which cannot easily be scratch-brushed, this brightening process is very serviceable. Care must be taken never to add too much at a time.

Preventing Electro-silver turning Yellow.—This change of colour is due to the deposit, by galvanic action, of pure silver and of subcyanide, which is rapidly decomposed and darkened by light. It is therefore necessary to remove the subcyanide by one of the following methods: (*a*) The articles are left immersed in the bath for some time after the electric current has been interrupted, when the silver subcyanide is dissolved by the potassium cyanide.

(*b*) Having smeared the objects with a paste of borax, they are heated in a muffle until the salt fuses and dissolves the subcyanide. This process anneals and softens the metal.

(*c*) The poles of the battery are inverted for a few seconds, that is to say, the articles become soluble anodes, and the electric current carries away the silver subcyanide in preference to the metal; this operation should be very short, otherwise the silver will entirely abandon the objects, and will coat the silver sheets.

Burnishing. — By burnishing, the roughness of an object is flattened down until the surface is smooth and polished, like a looking-glass. Burnishing is an important operation for electro-deposits which consist of a multitude of small crystals with intervals between them, and with facets reflecting the light in every direction. The deposited metal is hardened, and forced into the pores of the underlying metal, and the durability is thus increased to such an extent that with the same amount of silver a burnished article will last twice as long as one which has not been so treated. The instruments employed for burnishing are made of different materials, and must be of great hardness and a perfect polish. Such are hardened cast steel, agate, flint, and bloodstone. For metallic electro-deposits, steel and bloodstones are especially employed. There are several qualities of bloodstone; its grain should be close, hard, and without seams or veins; it should leave no white lines on the burnished parts, nor take off any metal, and its colour should be of an intense black-red. The steel must be fine and close grained, and perfectly polished. Should the polish of any burnishing tool alter by use, it is restored by friction upon a skin or leather attached to a wooden block which is fixed to the bench. The leather is covered with polishing rouge in impalpable powder, or, preferably, with pure alumina obtained by calcining ammonia alum in a forge fire. Venetian tripoli, rotten-stone, tin putty, emery, or many other hard substances finely powdered may be employed. The burnishing tools are of various shapes, such as a lance, a tooth, a knife, a half-sphere, or a dog's tongue, and a considerable stock is necessary. The burnishing is divided into two distinct operations: the first consists in roughing, and the second in finishing. The tools for the first have a sharp edge, whilst for the second operation they have a rounded surface. The tools for the hand or the lathe are fixed by copper ferrules into short, round wooden handles, so that the hand is not influenced by their weight; the tools for the arm or the vice are fastened to wooden handles sufficiently long to rest their slender part upon the arm or the shoulder, the stouter lower portion is grasped by the hand. The burnishing tools and the objects must be frequently wetted by certain solutions, some of which facilitate the sliding of the instrument, or with others which have a chemical action upon the shade of the burnished articles. Of the first are pure water, solutions of soap, decoctions of linseed, and infusions of the roots of marshmallow or liquorice; the second includes wine-lees, cream of tartar, vinegar, alum in water. When burnishing gold applied upon electro-deposits of copper, as in gilding with a dead lustre by that method, use pure water for fear of producing a disagreeable red shade. A solution of green soap is sometimes preferred by operators, although when old it imparts an unpleasant tinge, owing to the sulphides of the liquor. When the burnishing is completed, the surface is wiped longitudinally with a soft and old calico rag. The polish obtained by burnishing is called black, when it reflects the rays like a mirror; and should the presence of mercury or a bad deposit prevent the tool from producing a bright surface, the object is said to be greasy. Articles which have been previously polished, and which generally receive a very trifling deposit, are not burnished, but rubbed with chamois leather and the best quality polishing-rouge. Too thick or too rapid electro-deposits cannot be burnished, but must be polished by rubbing with a leather and a mixture of oil and powdered pumice, tripoli, or tin putty. Coarse powders are used at the beginning, and impalpable ones at the end of the operation.

Polished silver deposits are more agreeable to the eye than burnished ones ; but the hardening of the latter renders them more durable.

Silvering Britannia Metal, Pewter, and all Combinations of Lead and Tin.—These are best placed in a solution containing a good deal of free cyanide, and the deposit should be rapid at first. The surface of the anode should be about three times that required for German silver, and the battery power strong, but not too intense. It is better not to disturb these articles in the solution at the beginning of the deposit. Afterwards they may be shifted for obtaining a uniform coat. If the articles, when they have been a short time in the plating bath, present an unequal surface, remove them, and brush over again as before; then, after well rinsing, return quickly to the bath, and allow them, if possible, to remain without further disturbance.

Silvering Copper Ingots.—The principal difficulties in plating copper ingots are, to bring the surfaces of the copper and silver into fusion at the same time, and to prevent the copper from scaling; for which purposes fluxes are used. The surface of the copper on which the silver is to be fixed must be made flat by filing, and should be left rough. The silver is first annealed and afterwards pickled in weak spirit of salt ; it is planished, and then scraped on the surface to be fitted on the copper. These prepared surfaces are anointed with a solution of borax, or strewed with fine powdered borax itself, and then confined in contact with each other by binding wire. When they are exposed to a sufficient degree of heat, the flux causes the surfaces to fuse at the same time, and when cold they are firmly united. Copper may likewise be plated by heating it, and burnishing leaf silver upon it ; so may iron and brass.

(*b*) *The direct way.*—The article should first be rendered free from rust by rubbing with emery-cloth, or by dipping it into a pickle composed of sulphuric acid 2 oz., hydrochloric acid 1 oz., water 1 gal. After the article has remained some time in this pickle, it should be taken out and the rust removed by a brush and wet sand. If the oxide cannot be easily cleaned off, it must be returned to the pickle. As soon as the article is rendered bright, it is washed in a solution of soda, for the purpose of removing all grease. Lastly, it is well rinsed in hot water, and immediately placed in the plating solution, which should contain only about one-fourth as much silver as that used for plating copper and brass articles. The battery power must also be weak. When the object receives a slight coating, the process may be carried on more rapidly by increasing the battery power, and by placing the article in a much stronger plating bath, using about 1 oz. silver in a gallon of solution. *The indirect method* consists in first coating the iron with copper, which insures success. Copper adheres firmly to iron, but silver does not ; hence copper acts the part of a go-between. After the article has been cleaned, as above described, it is coated with copper by placing it in a solution composed of carbonate of potassium 4 oz., sulphate of copper 2 oz., liquid ammonia about 2 oz., cyanide of potassium 6 oz., water about 1 gal. The sulphate of copper may be dissolved in warm rain-water, and, when cold, the carbonate of potassa and ammonia added ; the precipitate when formed is redissolved. The cyanide of potassium should now be added, until the bluish colour disappears. Should any precipitate be found in the bottom of the vessel, the clear solution may be poured off from it. The solution is worked cold, and with moderate battery power. Let the article remain in the bath until a thin film of copper is deposited, then remove quickly, rinse in hot water, and place in the silvering solution, where the process may go on as rapidly as if plating a copper article.

Tin.—(*a*) Argentine is a name given to tin precipitated by galvanic action from its solution. This material is usually obtained by immersing plates of zinc in a solution of tin containing 6 grm. (about 90 gr.) of the metal to the litre (0·88 qt.). In this way tin scrap can be utilised. To apply the argentine according to Marino's process, a bath is prepared from argentine and acid potash tartrate rendered soluble by boric acid. Soda pyrophosphate, ammonium chloride, or caustic soda, may be substituted for the acid tartrate. The bath being prepared, the objects to be coated are plunged therein, first having been pickled and scoured, and they may be subjected to the action of an electric current. But a simple immersion is enough. The bath for this must be brought to ebullition, and objects of copper or brass or coated therewith may be immersed in it.

(*b*) The bath is composed of rain or distilled water, 110 gal.; pyrophosphate of soda or potash, 11 lb.; crystallised protochloride of tin, 21 oz.; or 18 oz. of the same salt fused, in order to have it free from an excess of acid; put the water into a tank entirely lined with anodes of tin sheets, united together and connected with the positive pole, carbon or copper, of the battery. Then introduce the pyrophosphate, and stir it in; when dissolved, the tin protochloride is put into a sieve of copper half immersed in the solution. A milky-white precipitate is produced, which disappears after continued agitation. When the liquid has become clear and colourless, or only slightly yellow, the bath is ready; then place upon transverse metallic rods, connected with the negative pole, the previously cleaned objects which are to be tinned. The anodes are not sufficient to keep the bath saturated; when the deposit is too slow add small portions of equal weights of tin salt and pyrophosphate; put in by the aid of the sieve, as if fragments of protochloride fall to the bottom of the bath they become covered with a crust, which prevents their solution. The tinning thus obtained upon any kind of metal is quite resisting, and has a white and dead lustre resembling that of silver. A bright lustre may be obtained with the scratch-brush or the burnishing tool. The reduction of these baths requires an intense current, and the working of the batteries is expensive. (*And see* page 131.)

Galvanoplasm. Thick Deposits.—Galvanoplasm consists of deposits with sufficient thickness to form a resisting body, which may be separated from the objects serving as moulds, and which will preserve the shape and dimensions of the model. A statue of plaster of Paris, wood sculpture, an impress in wax, fruit, and similar things, may, after certain preparations, be covered with electro-deposits, for instance, which will give a deposit representing the same shape and dimensions. In galvanoplastic operations copper is almost exclusively employed. It is possible to have the deposits entirely of silver and gold; but these are exceptions, on account of the cost of the materials and of the difficulties of the operation. The following is a summary of the usual requirements: (1) To apply upon a metallic surface conductor of electricity, a deposit of copper adhering to the metal underneath. (2) The above operation being completed, the two metals must be separated in such a manner that they will furnish two identical productions, one of which will be in relief, and the other hollow, for casts of medals, etc. (3) To apply the electro-deposits upon substances not naturally conductors of electricity, but rendered so by the process of metallisation; upon ornaments of plaster of Paris, wax, glass or porcelain, or upon leaves, fruits, and insects. (4) After the deposit to separate the non-metallic model to have a perfect copper copy of it. For reproduction of type in stearine, gutta-percha, gelatine. (5) Or, if it is impossible to apply the electro-deposit of copper directly upon the model, make moulds upon which a greater or less number of copies may be obtained. This is the general case: The imprint of the model is taken with a plastic substance, which is rendered a conductor of electricity, and upon which the galvanoplastic deposit is effected.

THE BATHS.—(1) Put into a vessel, made of glass, stoneware, porcelain, gutta-percha, or lead, a certain quantity of water, to which is added 8 to 10 per cent. of sulphuric acid. If in a glass vessel, or one lined with gutta-percha, pour in the acid slowly and stir all the time, otherwise the acid, which is much denser than water, falls to the bottom, and slowly combining with the surrounding water, may cause an increase of temperature sufficient to break the glass or melt the gutta-percha.

(2) Dissolve in this liquor as much copper sulphate as it will absorb at the ordinary temperature. Stir frequently with a glass or wooden rod, to mix the solution; or the copper sulphate may be put into a perforated ladle of copper or stoneware, or into a bag of cloth, fixed near the surface of the liquid. When the liquid refuses to absorb any more crystals, it is saturated, and marks about 25° B. Baths of copper sulphate, while they are working, must always be kept saturated; new copper sulphate must be introduced to replace that decomposed and forming the metallic deposit; for this purpose suspend from the top of the vessel, and in the upper portion of the liquid, bags filled with crystals of copper sulphate. It is necessary to use good copper sulphate; the best is in crystals, semi-transparent and of a fine olue colour. Its solution is also a pure blue. These baths are always used cold, and are kept in vessels of shapes adapted to the wants of the operator. Stoneware, porcelain, and glass are the best materials for the purpose; but as it is difficult to find vessels sufficiently large, wooden troughs covered inside with coats of gutta-percha, marine glue, or with a sheet of lead, are used, painted with resist varnish.

Deposits by Separate Batteries.—After proper preliminary operations, the object which is to receive the deposit is connected with the conducting wire attached to the negative pole of the battery, zinc generally, and immersed in the solution; and the conducting wire starting from the positive pole, carbon or copper, is attached to a foil or plate of copper, and this anode is placed in the liquor parallel to the object connected with the other pole. This plate should have a surface at least equal to that of the article to be covered. The deposit will begin immediately, and its progress may be seen by removing the object from the solution. If upon a clean metallic substance, the deposit of copper will be instantaneous on every part of it; if, on the contrary, the surface only moderately conducts the electricity, as graphite, the deposits will begin at the points touched by the conducting wire, and then proceed forward. With a little practice it is easy to ascertain whether the intensity of the current corresponds to the surfaces to be covered. The operation will be slow with a weak current, but there is no other inconvenience, unless the substance of the mould is alterable, like gelatine. Too intense a current results in a granular deposit, of which the particles have little cohesion between themselves, and no adherence to the mould.

Simple Apparatus for Amateurs.—Place the solution of copper sulphate in a stoneware, earthenware, or porcelain vessel, in the centre of which stands a porous cell filled with water with 2 or 3 per cent. of sulphuric acid, and 1 per cent. of amalgamating salt. This liquid must surround an inner cylinder of zinc, upon the top of which rests a circle of brass wire, by two crossed bars soldered or fixed in four notches on the top of the zinc cylinder. Suspend from this circular framework, projecting over the copper solution, a certain number of objects or moulds, immersed in the liquid in such a way as to have their faces to be covered near and opposite to the cell. Two small hair bags filled with copper sulphate crystals, should be attached to the upper edge of the vessel.

Large Apparatus.—To cover large

surfaces, use a bath contained in a large wooden trough, lined inside with gutta-percha, or lead, or other substance unacted upon by the bath. In the middle of the trough dispose a row of cells close to each other, and each with its zinc cylinder. Connect a thin metallic ribbon with all the binding screws of the cylinders, in contact at its extremities with two metallic bands on the ledges of the trough. The metallic rods to support the moulds are placed in contact with the metallic bands of the ledges, and therefore in connection with the zincs. If the objects are in high relief, use a circular trough, place the cells in a circle, and the mould to be covered in the centre. Whatever the shape of the mould, its position should now and then be changed, because the lower layers of the bath give more abundant deposits, owing to the difference of specific gravity of the layers more or less charged with sulphate. As far as practicable, maintain the liquids in the bath and in the cells at the same level; or it is better to have that of the bath slightly above that of the cell, to prevent the solution of zinc from mixing with the copper bath.

Porous Cells.—Pipeclay, pasteboard, bladder, gold-beater's skin, parchment, sail-cloth, and certain kinds of wood may be employed, but nothing equals porcelain clay, submitted to a certain heat, which hardens the paste without destroying its porosity. Vases made with this material are just porous enough, and resist the action of concentrated acids.

Batteries.—The battery will work well for 24 hours; and, for four consecutive days, it will only be necessary to add small quantities of acid and amalgamating salt, in proportion to the volume of the cells. Stir the mixture each time with a glass rod. The fifth day, throw away all the exciting liquors, and substitute fresh ones, otherwise the zinc salt will be so abundant as to crystallise upon the zincs and the cells. A cell may be clogged in two ways (1) by the zinc sulphate, which having an insufficiency of water, crystallises in the pores; in this case boil the cells in water acidulated by sulphuric acid. (2) By deposits of copper caused by bad working; dip the cells in aqua fortis until all the copper is dissolved, and rinse in plenty of water afterwards. It is also possible to clean cells by keeping them filled with water, which, escaping through the pores, pushes out the salts and the acids with which they are clogged. Cast zinc will work, but is far inferior to laminated zinc, which will be uniformly corroded instead of being perforated. It sometimes happens that zinc is scarcely attacked, even by concentrated liquors, and that a multitude of small cavities are engraved on its surface. It also becomes covered with a blackish-grey crust, and no electricity is disengaged. These inconveniences occur when the zinc is too rich in lead.

Amalgamating Salt.—To avoid the solution of the zinc when the apparatus is not at work, cleanse it in dilute hydrochloric acid, and then amalgamate it by rolling the cylinders in a trough filled with mercury.

Acid Baths.—When a bath contains too weak a solution of copper sulphate, the electro-deposit is pulverulent, black and irregular. The same inconvenience occurs when the liquors become too acid, because they do not dissolve enough copper sulphate. When the bath is too acid, add copper carbonate until effervescence no longer takes place. The bath should then be acidified anew to increase its conducting power. The copper carbonate may be replaced by the oxide of the metal, which dissolves without effervescence. If, after very long use, a bath becomes overloaded with free acid and zinc sulphate, there is no remedy but to start a fresh one.

Placing the Pieces in the Bath.—The depth of the bath should be sufficient to have a little liquor above and below the moulds. If the moulds are lighter than the solution of copper sulphate, sink them with lead pieces covered with varnish, with stones, or other non-conductors of electricity. When the object to be covered is metallic, and unacted upon by the solution of copper sulphate, attach the conducting wire to any part of its surface, and it will be rapidly covered with a uniform deposit; if the mould is a non-conductor of electricity and has been covered with some conducting substance, such as plumbago, bronze powder, or reduced silver, multiply the points of contact as much as practicable, of the electrode, by uniting the connecting wire with a number of fine copper wires, and making their bent extremities touch the mould at various places. This method gives a greater rapidity of operation, and a uniform thickness of deposit. It is especially necessary for moulds having deeply indented surfaces. As soon as the surface is entirely covered remove the supplementary wires. If only one face of the mould is to receive the deposit, protect the other surfaces by a resist varnish, melted yellow wax or softened gutta-percha.

Adhesive Deposits upon Metals.—Metals are unequally qualified to receive the galvanoplastic deposit; and some are naturally unfit for it. For instance, wrought and cast iron, steel, and zinc, as soon as immersed in the solution of copper sulphate, and without the aid of electricity, decompose the salt, and are coated with a muddy precipitate of copper, without adherence. It is necessary to give them previously a thick coat of copper in the bath of double salts before submitting them to the action of the sulphate. Tin, although presenting these inconveniences in a much less degree, should also be copper electroplated in the solutions of double salts, before going into the bath. When the metal to be covered is unacted upon by the bath, cleanse it well, and submit it to the action of the current, which will give a rapid and uniform deposit; this should not be too thick, otherwise the surfaces may have a coarse appearance, which impairs the fineness of the lines of the mould. With a good bath, and a well-regulated electric current, the delicacy of the pattern will not be defaced by a copper coat having the thickness of stout writing paper. A bright lustre may be obtained by scratch-brushing or burnishing; or by a passage through aqua fortis and soot, and afterwards through the compound acids for a bright lustre.

Dead Lustre Gilding by Galvanoplastic Deposit.—Adhering galvanoplastic deposits give a very cheap and handsome gilding with a dead lustre, which, although not equal in durability, has the appearance of that obtained with mercury. Having cleansed the mould if metallic, or rendered it a conductor if non-metallic, immerse it in the solution of copper-sulphate, and allow the deposit to acquire a dead lustre slightly in excess of that desired. After this operation, which may last 2 to 6 hours, remove the article from the bath, rinse it in plenty of water, and pass it rapidly through the compound acids for a bright lustre, which diminish the previous dulness of the appearance. Next rinse in fresh water; steep in a mercurial solution similar to that employed for gilding by dipping; rinse again, and immerse in an electro-gilding bath made of—Distilled water, 2⅕ gal.; soda phosphate, 21 oz.; soda bisulphite, 3½ oz.; potassium cyanide, ⅔ oz.; gold, for neutral chloride, ⅓ oz. At first, the current is rendered sufficiently intense by dipping the platinum anode in deeply; afterwards the intensity is diminished by partly withdrawing the anode until the entire shade of gold is obtained. This gilding requires but little gold, as the frosty dead lustre comes from the copper. When the lustre of the copper is very fine and velvety, dispense with the dipping into the compound acids, but the rapid passage through the mercurial solution is always desirable. If the deposited gold is not uniform, or appears cloudy, it is proof of an imperfect deposit in the bath, or of an insufficient steeping in the compound acids. The piece should then be removed from the bath, washed in a tepid solution of potassium cyanide, rinsed in fresh water, dipped in the solution of nitrate of mercury, and electro-gilded anew. This gilding bears burnishing well; avoid acid waters and soap, which will produce a red polish, and use only the fresh solutions of linseed, or of marshmallow root. The tone of gold thus obtained is richer, deeper, and more durable than that produced upon frosted silver, the latter being recognised by the green colour of the burnished parts. This kind of deposit may be employed for binding substances together, because the covering coat will be continuous.

Galvanoplastic Deposits without Adhesion.—After thoroughly cleaning the pattern, rub it with a brush charged with plumbago, or with a soft brush slightly greased by a tallow candle. The film of fatty substance should not be seen at all. The deposit obtained represents an inverted image of the pattern, and the raised parts become hollow. Remove the mould, and perform the same operation upon the deposit; this second deposit is the accurate reproduction of the first pattern.

Deposits upon Non-Metallic Substances.—By this process, porcelain, crystal, plaster of Paris, wood, flowers, fruit, animals, and the most delicate insects may be coated. These substances have no conductive power for electricity; it is, therefore, necessary to metallise them.

Metallisation.—This coat should be so thin as not to alter the shape or the minutest parts of the model.

Plumbago (graphite) is generally preferred, and in most cases its conducting power is sufficient; it may be applied in films thin enough not to impair the sharpness of the mould. The plumbago found in the trade is rarely pure. Remove the impurities by digesting for 24 hours a paste made of plumbago and water, with hydrochloric acid. Several washings with water, and slow drying in a stove, finish the operation. If the plumbago is in large lumps, it should be powdered and passed through a silk sieve. The conducting power of this substance is sufficient when the surfaces are not deeply indented; but the mould should be rough enough for the plumbago to stick to it.

Gilt Plumbago has a conducting power much greater than that of the ordinary substance. Prepare as follows: In 1¾ pint sulphuric ether dissolve ⅛ oz. gold chloride, and thoroughly mingle with it 18–20 oz. good plumbago. Then pour into a shallow porcelain vessel, and expose to the action of air and light. After a few hours, the ether completely volatilises; stir the powder now and then with a glass spatula. Finish the drying in a stove.

Silvered Plumbago.—Dissolve 3 oz. crystallised silver nitrate in 3 pints distilled water; mix this solution with 2 lb. good plumbago. Dry in a porcelain dish, and then calcine at a red heat in a covered crucible. After cooling, powder and sift. Plumbago thus metallised conducts electricity nearly as well as a metal, although it is very expensive. Bronze powder mixed with plumbago is also used.

Rendering Moulds Impervious to Liquids.—Porous substances, before being coated with plumbago, are submitted to a previous operation, to render them impervious, by covering them with a coat of varnish, or by saturating them with wax, tallow, or stearine. For instance, with a plaster cast, cut a groove on the rim of the mould, place in it a brass wire, twist the ends, which must be long enough to hold the cast by. The cast, having been previously dried, is then dipped into a bath of stearine kept at a temperature of 180°–212° F., and a number of bubbles of air will escape from the mould to the surface. When the production of air-bubbles is considerably diminished, remove the cast from the bath. When the cast is tepid, cover it with powdered plumbago, and let it get quite cold. Then, after breathing upon it, rub thoroughly with a brush covered with plumbago; and be careful that the surfaces are completely black and bright, without grey or whitish spots. When the mould is very undercut, it is difficult to employ plumbago. In such cases metallise the whole, or the deep parts only, by the wet way. Soft brushes should not be used for rubbing plumbago. When the substances to be metallised are not porous, such as glass, porcelain, stoneware, horn, and ivory, cover them with a thin coat of varnish, which, when nearly dry, receives the plumbago.

Metallisation of Ceramic Articles.—After having varnished the portions of the piece to be covered, cover them with very finely laminated foils of lead, which bend to all desired shapes; then connect a brass conducting wire with the lead, and dip the whole into the bath; copper is immediately deposited upon the metallic parts. Thus glass vases may be entirely covered with copper, upon which deposit layers of gold or silver. The chaser may penetrate with his tool to different depths, and uncover one after the other, first the layer of silver, next that of copper, and at last the crystal itself. The vase will appear as if set in a net of various colours. For very fine work, the gold ornament first painted with the pencil, and fixed in the usual manner by heating in a muffle, is put in contact with a very thin conducting wire, and the whole is immersed in a copper, silver, or gold bath, where the deposit takes place in the same manner as upon an ordinary metal, and the adherence is as perfect as that of the film of gold upon the porcelain. The deposit is afterwards polished, chased, or ornamented on the lathe.

Metallisation by the Wet Way.—Silver, gold, and platinum, reduced from their solutions, have an excellent conducting power. Silver is generally preferred, and its nitrate is dissolved in certain liquids, variable with the stances to be covered. Apply the solution with a pencil upon the mould, and let it dry; repeat the operation two or three times. Lastly, expose the mould to the action of the sunlight, or of hydrogen, or fix it to the top of a box which closes hermetically, and at the bottom of which is a porcelain dish holding a small quantity of a concentrated solution of phosphorus in carbon bisulphide. After a few hours this solution completely evaporates, and reduces to the metallic state the silver nitrate covering the mould, which becomes black, and is then ready for the bath. When used to metallise wood, porcelain, and other resisting substances, dissolve 1 part silver nitrate in 20 of distilled water. With fatty or resinous materials, which water will not wet, use aqua ammonia. With very delicate articles, which will not bear a long manipulation, make the solution in alcohol, which evaporates rapidly. Concentrated alcohol dissolves silver nitrate but slightly; but enough will be dissolved for metallising flowers, leaves, and similar articles, if the solution is aided by grinding in a mortar. If the conducting wire is fixed to the mould before the metallisation, the wire must be of gold, silver, or platinum, as the other metals rapidly decompose the solution of silver nitrate; but brass and copper wires may be employed when the metallisation is completed, after the reduction by phosphorus.

Solution of Phosphorus in Carbon Bisulphide.—Half fill a glass-stoppered bottle with a large neck with bisulphide, then gradually introduce the phosphorus gently dried with blotting paper, and shake the bottle now and then. Phosphorus is added until no more dissolves. This preparation requires great care in the handling, because in drying upon combustible materials it takes fire spontaneously.

Plaster of Paris Moulds.—After the original model, say a medal, has been thoroughly rubbed with soap or plumbago, wrap round the rim a piece of stout paper, or thin lead foil, and bind it in such a manner that the article to be copied, face upwards, is at the bottom of the box thus formed. Then in a vessel filled with a sufficient quantity of water, sprinkle fine plaster of Paris until the last portions reach the level of the water. After waiting for one or two minutes, stir, and the thin resulting paste must be employed immediately. With a painter's brush give a thin coat of this paste, and press into all the recesses; this is to expel the air; then pour the remainder of the paste up to a proper height, and allow it to set. After a few minutes the plaster hardens, and may be separated from the paper. Scrape off what has run between the paper and the rim of the medal, and the plaster cast will separate from the model. Plaster of Paris moulds cannot be introduced into the bath without having been previously rendered impervious.

Moulding with Stearine and Wax.—Stearine is melted and poured upon the model when it is going to set. When stearine is too new or dry, it crystallises in cooling, and this impairs the beauty of the cast. In such case it should be mixed with a few drops of olive-oil, or with tallow, or suet; if it is made too fat, it will remain soft and difficult to separate from the mould. It should then be mixed with virgin wax or spermaceti. As stearine contracts considerably by cooling, its employment must be avoided when the copies are required to be perfectly accurate. When it is decided to make a cast with stearine of a plaster model, the latter should be thoroughly saturated with water or stearine beforehand, and should also be perfectly coated with plumbago before the melted substance is poured upon it, otherwise the two will stick together, and it will not be possible to separate the cast from the model. Wax may also be employed in the same manner, but its price and want of hardness interfere with its application.

Moulding with Fusible Metal.—This metal is a perfect conductor of electricity, and therefore well adapted to the production of homogeneous deposits of equal thickness; it is, however, seldom employed, on account of the difficulty of the operation, of its crystalline texture, and of the presence of air-bubbles.

Fusible alloys are: (*a*) Pure lead, 2 parts in weight; tin, 3; bismuth, 5; fusible at 212° F. (*b*) Pure lead, 5 parts in weight; tin, 3; bismuth, 8; fusible at 180°-190°F. (*c*) Pure lead, 2 parts in weight; tin, 3; bismuth, 5; mercury, 1; fusible at 158° F. (*d*) Pure lead, 5 parts in weight; tin, 3; bismuth, 5; mercury, 2; fusible at 125° F. For those alloys without mercury, the component metals may be melted together; when mercury is employed, it should be added when the three other melted metals have been removed from the fire. To obtain a thorough mixture the alloy should be stirred with an iron rod, or melted over and cast several times.

Run the metal into a small dish, remove the oxide with a card, and then apply the model, give it a few taps when the setting takes place; or put the model into the dish, and pour the clean alloy upon it. Or, put the medal at the bottom of a small box of iron or copper, and bury half its thickness in plaster of Paris; then, cover the medal with the cold fusible alloy, and apply heat until melted, when it is allowed to cool off. It is easy to separate the medal from the fusible alloy, as the portion protected by the plaster of Paris may then be grasped. A well-made cast of fusible alloy is the best mould for galvanoplastic operations with silver and gold. Alloys containing mercury should not be used for taking casts from metallic medals, iron excepted, which would be amalgamated and injured. Copper deposits obtained upon such alloys are very brittle. Melted sulphur produces very neat and sharp casts; it is, however, very difficult to get it metallised, and it transforms the deposit of copper into sulphide.

Moulding with Gelatine.—In certain conditions, the elasticity of gelatine and gutta-percha allows of removing them from undercut or highly-wrought parts, and they reacquire the shape and position they had before the removal. This property is found in gelatine to a higher degree than in gutta-percha, but it requires a very rapid deposit, otherwise it will swell and be partly dissolved by too long an immersion in the solution of copper sulphate. Put sufficient colourless gelatine in cold water, and let it swell there for about twenty-four hours; then drain off the water, and heat the gelatine upon a water bath until it has become of a syrupy consistency; it is then ready to be poured upon the object, which must be encased in a box of pasteboard or of thin lead. After cooling for about twelve hours, separate the cast from the object. To enable the gelatine to remain longer in the bath without alteration, use one of the following mixtures :—

(*a*) Dissolve the best gelatine in hot water, and add $\frac{1}{60}$ of the weight of gelatine in tannic acid and the same quantity of rock candy; then mix the whole thoroughly, and pour upon the model in its box. After a few hours the gelatine may be easily separated from the object.

(*b*) A mould having been made with gelatine alone, pour on it a solution of water holding 10 per cent. potash bichromate, and after draining, expose the mould to the action of the sun.

(*c*) Beat in 2 pints distilled water, the whites of 3 eggs, filter, and cover the entire surface of the gelatine mould with this liquid. After drying, operate with the solution of potash bichromate, as in (*b*).

(*d*) Pour some varnish upon the gelatine mould, drain carefully, and let it dry. The best varnish for the purpose is a solution of rubber in benzole, or in carbon bisulphide. The mould must be metallised, and, when in the bath, submitted to a galvanic current of great intensity at the beginning. When the entire surface is covered with the copper deposit, and swelling is no longer to be feared, the intensity may be reduced.

Moulding with Gutta-percha.—Gutta-percha is entirely insoluble in water, in weak acids, and in the solution of copper sulphate. After purification in boiling water, plates of various thicknesses or lumps are formed. A quantity sufficient for the intended mould is cut and put in cold water, which is gradually heated, until it is soft enough to be kneaded with the fingers like dough. After having pulled the gutta-percha in every direction, the edges are turned in so as to form a kind of half ball, the convex and smooth surface of which is then applied upon the middle of the model. Then the gutta-percha is spread over and forced to penetrate the details of the object. The kneading is continued so long as the material remains sufficiently soft, when it is allowed to cool. As soon as it is lukewarm, the gutta-percha is separated from the model, and dipped into cold water, when it hardens, and may then be handled without danger of impairing its accuracy.

Moulding with the Press.—After the object has been carefully coated with plumbago or tallow, it is put square and firm upon the table of the press, and surrounded with a ring or frame of iron, which should be a little higher than the most raised parts of the object. A piece of gutta-percha, at least double the thickness of the pattern, is cut so as to fill the ring or frame of iron, and then heated, on one of its faces only, before a bright fire. When about two-thirds of its thickness have been softened, it is to be placed, soft portion downwards, in the iron ring or frame, and the whole covered with a block of metal exactly fitting. The screw to the press is made to act slowly at first, but with gradually increased force, as the gutta-percha becomes harder and more resisting.

Moulding with a Counter-mould.—Cast a thin block of lead upon sand; hollow out approximately with a graver the places corresponding to the reliefs of the pattern, bearing in mind the desired thickness of the gutta-percha. Spread over the pattern a plate of gutta-percha of the same thickness all through; upon this place the lead block; compress by the screw press. This process produces excellent results.

Moulding in the Stove.—This is convenient for brittle articles of plaster of Paris, marble, or alabaster. The pattern is put upon a dish of iron or earthenware, a ball of gutta-percha is placed in the middle of the object to be moulded, and the whole is placed in a stove, where the temperature is just sufficient to melt the gutta-percha, which softens and penetrates all the details; when it has sunk completely, remove it from the stove, and allow to cool off until it still retains sufficient elasticity to be separated from the pattern.

Moulding by Hand.—The foregoing process does not suit objects which will not bear the heat of the stove; for such articles heat the gutta-percha slowly until it becomes a semi-fluid paste; pour a sufficient quantity of it upon the pattern previously placed in an iron frame or ring. After a few minutes, knead it, with wet or oiled fingers, to make it penetrate all the details of the pattern until it scarcely yields to the pressure. In removing the mould from the pattern, cut off all the useless parts of the gutta-percha, and especially those which may have passed under the pattern and bind it. Then the proper position and shape of the covered pattern must be ascertained, so as not to break the model, or tear the gutta-percha. In moulding with the press, gutta-percha of the best quality is generally employed. For moulding by sinking or kneading, gutta-percha should be mixed with certain substances to increase its fusibility, such as linseed-oil, lard, tallow, or yellow wax. Their proportions should never be over one-third of the total weight. The mixture with linseed-oil is made by heating in a kettle 1 part linseed-oil, and when its temperature has reached 190°–212° F., add gradually, and stir in 2 parts gutta-percha cut into small pieces. When the whole is in a pasty form, and begins to swell up with the production of thick fumes, remove the kettle from the fire, and throw its contents into a large volume of cold water, where, without loss of time, the paste must be well kneaded. While still hot, place it upon a slab of marble or stone; it may afterwards be rolled between middling warm rollers. Gutta-percha may be used for an indefinite length of time. Models of plaster of Paris, from which moulds of fusible metal or of gelatine are to be taken, will stand the operation much better if they have been hardened by being saturated with boiled linseed-oil, to which a certain proportion of dryer has been added. They must be oiled again just before pouring the gelatine over them.

Deposits on Undercut Patterns which are Sacrificed.—A cast of a human head in plaster of Paris may be rendered impervious, and then metallised. After a deposit of copper has been effected on its surface, remove the plaster by boiling, and breaking it through the opening of the neck. The copper mould thus obtained, after being slightly greased inside, serves as a galvanoplastic trough, which is to be filled with the solution of copper sulphate. Suspend bags filled with crystals of blue vitriol to the edges, and with a separate battery and soluble anode, or with a porous cell placed inside the mould, which is connected with the zinc, another deposit of copper takes place in the cavity. When the thickness of the metal is sufficient, strip off the mould or first deposit. This process is expensive, but gives sure results with large patterns having large raised parts. With small or narrow, or very crooked objects, moulds in several parts must be used, although the seams require mending.

Method for Articles in High Relief with Gutta-percha Moulds.—If it is required to imitate a statue, or other large article, commence by making with gutta-percha a mould in several pieces, which, by means of proper marks, may be united together, and form a perfect hollow mould of the pattern. Cover all these parts carefully with plumbago. Make a skeleton with platinum wires, to represent the outline of the pattern; this must be smaller than the mould, as it has to be suspended in it without any point of contact. The skeleton is to be enclosed in the metallised gutta-percha mould, and the whole immersed in the galvanoplastic bath; connect the inner surface of the mould, with the negative pole of the battery, and the skeleton of platinum wires, which should have no point of contact with the metallised surface of the mould, with the positive pole; this decomposes the solution of copper sulphate, which must be placed in the mould. When the deposit has reached the proper thickness, remove the gutta-percha mould, inside which will be found the statue, which may be finished at a very small expense. Lead wires may be substituted for the platinum, they are cheaper, and may easily be removed, when done with, by melting. But the execution of the process is not easy, as it is very difficult to ascertain that the skeleton anode is nowhere in contact with the enclosing mould; to avoid such contact, wrap all the external parts of the platinum anode with a spiral of rubber thread. As the increase of the deposit of copper reduces the distance between the mould and the anode, the latter and the deposit may come in contact, and stop the operation without any exterior sign to attract attention, Thus, if in a trough holding many moulds, one point of contact were established between the two poles, mould and skeleton, all the electricity of the battery would escape at that place, and the working of the bath would stop entirely. To obviate this inconvenience, support all the moulds of the same bath by hooks suspended from a metallic rod. These hooks must have no contact with the metallised surfaces of the moulds, which must be connected with the negative pole by metallic wires terminated above the liquid by very fine iron wires. The connecting wires of the skeleton anode are to pass through the same opening as the negative electrodes, but without contact, and are united to the positive pole. So long as there is no contact between the skeleton and the interior of the mould, the electric fluid finds sufficient passage through the several fine iron wires which connect the moulds with the battery; but, if any contact takes place, the whole of the electricity rushes to that point, and, being too abundant for the small iron wire, it heats and burns it out rapidly. The work is thus instantaneously stopped for this mould, and continues for the others; and the broken wire shows where the defect is. The iron wire should be very short, so as to burn rapidly. In closed moulds and with an insoluble platinum anode, the solution of copper sulphate will be rapidly transformed into sulphuric acid and water. Therefore make two holes at the lower part of the mould, through which and the opening at the head left for the passage of the electrode a free circulation of the liquor in the bath may take place. When the operation is completed, remove the gutta-percha mould, and the skeleton anode must be pulled out. Close the three holes in the statue, and file off the seams left at the junction of the different parts of the mould.

Filling the Hollow Deposit with Brass Solder.—First cover the exterior with clay, plaster of Paris, or Spanish white mixed with charcoal dust, and dry in a stove-room. This coat is to prevent the copper deposit from losing its shape and being oxidised by the heat. The interior of the article is then to be filled with the softest brass solder and powdered borax, which are melted by a gas or turpentine blowpipe. All the hollow parts are soon filled with the solder, which imparts to them as much firmness and durability as is to be found in cast articles.

Removing the Mould.—With a metallic mould, after having removed the useless portions of the deposits, pass a card or a blade of ivory between the model and the deposit. The operation is the same with moulds of plaster of Paris, porcelain, marble, glass, or wood; but it is difficult to save a plaster mould which has been in the bath, and which is nearly always sacrificed. Moulds of wax, stearine, fusible metal, gelatine, or gutta-percha are softened in boiling water, and their separation presents no difficulty whatever.

Finishing up the Articles. — The articles when separated from the moulds are generally spotted with plumbago, grease, or other substances from the moulds. It is usual to heat them, so as to burn out the impurities, and to cleanse them by immersion in a pickle of dilute sulphuric acid. The heating renders the copper deposit softer and more malleable; but it may result in injury to the minute details and the fineness of the copy. Therefore, for delicate works, it is preferable to clean with alcohol, turpentine, or benzole, and to rub the surface with a stiff brush; finish with a paste of Spanish white in water, which let dry upon the object before it is wiped out. Should any Spanish white remain in the hollows, it may be dissolved in water holding one-tenth of its volume of hydrochloric acid, which does not corrode the copper. Complete the operation by rinsing in fresh water, and drying in sawdust or otherwise. When it is desired to anneal the articles without injury to their surface, plunge them into boiling colza or linseed oil, or simply grease, which will bear a heat sufficient for annealing, and will prevent the oxidising action of the air. This annealing in fatty substances is to be recommended in the case of highly undercut moulds of gutta-percha, which may have left part of their substance in the deep recesses of the copy. The gutta-percha is first softened, and then dissolved in the fatty material.

Galvanoplastic Operations with Gold or Silver.—The processes are more difficult and less effective than those for copper. In the case of non-conducting and deeply-wrought moulds, after having deposited by the ordinary process a thin coating of copper, the whole is plunged into the silver bath, which then works very well. After the separation of the copy from the mould, allow it to rest in a solution of ammonia or of very dilute nitric acid, which, after a time dissolves the copper, and leaves the silver deposit. This reproduction must be imperfect, as there is, between the mould and the precious metal, an intermediate layer of copper of unequal thickness. When the surfaces are but slightly in relief, employ moulds of lead, tin, or fusible metal, upon which silver or gold will deposit well and without adherence. Lead is preferable to the other metals, especially when the mould may be obtained by pressure. Cover the pattern with a very thin foil of lead larger than the object, the gutta-percha is applied upon it, and pressed, as before explained. The lead foil, without being torn, will follow all the details of the pattern, and may be separated afterwards with the gutta-percha which it has metallised. Instead of lead, silver or gold foils may be used, and are so thin that the seams disappear by simple pressure. A somewhat thick sheet of very pure lead may be employed for taking moulds of engravings upon copper or steel. The lead and the engraved plate are to be passed between rollers, or simply pressed under a screw press.

Baths for Silver and Gold.—The bath for silver is composed of distilled water, 1¾ pint; potassium cyanide, 7 oz.; nitrate of silver, fused, 2½ oz. The gold bath is made of distilled water, 2 pints; potassium cyanide, 6 oz.; neutral gold chloride, 2 oz. These baths generally work with separate batteries, and with anodes of the metal used in the solution, or the porous cells and zincs may be put into the bath itself, provided that the exciting liquor be a more or less concentrated solution of potassium cyanide. The zincs must not be amalgamated, unless in separate batteries. Green gold is obtained by mixing 10 parts gold bath with 1 of silver bath, or by employing for a time a silver anode in the gold solution. The deposits of gold and silver, after their separation from the mould, should be heated and scratch-brushed; and a proper shade may be given to them by a short sojourn in ordinary electro-gilding or silvering baths.

* * *

EMBALMING.

(*See also* PRESERVING, TAXIDERMY.)

IT has been remarked by Dr. B. W. Richardson that the ancient methods of embalming, when compared with the present, were singularly rough and laborious; yet in those ancient plans are to be found the principles of preservation carried out in perfection — rudely, but perfectly. The Egyptian embalmers commenced proceedings by extracting the brain of the dead person from the cavity of the skull, through the nostrils, by means of a hook, and by the pouring of infusions of certain drugs into the cavity of the skull. In these ways they removed the brain without disfiguring the head or face. The abdominal cavity was next opened with a sharp Ethiopic stone, and the intestines were taken out.

After the cavity of the body was emptied of its natural contents, it was charged with powder of pure myrrh, cassia, and other perfumes, but not frankincense. The body was then sewn up, and covered with nitre and natron for 70 days. At the end of that period, the body was removed, washed, and closely wrapped in bandages of cotton dipped in a solution of gum arabic, which the Egyptians used as glue. It was now returned to the relations, who enclosed it in a case of wood. Pettigrew, who unrolled many mummies, is of opinion that, before the bandaging was carried out, the cuticle or scarf skin of the body was peeled off, the nails being carefully preserved. The nails were sometimes gilded; these nails and the hair were well preserved.

A second and less expensive process was performed without emptying the cavities of the body at all. The intestinal cavity was injected with cedar oil, and the whole body was afterwards covered with nitre for 70 days, as in the first instance.

The third and least expensive process was simpler still. The inside of the body was washed with a solution called syrmaea, and then the body was covered with natron for 70 days. The nature of syrmaea, or, as some spell it, surmia, is not known. It was probably an aromatic solution.

Herodotus tells of another mode of preserving the bodies of the dead. He says of the Macrobian Ethiopians that they extracted the moisture from the bodies of the dead, and then, covering each body with a kind of plaster, they decorated the plaster with various colours, so as to imitate the dead as closely as possible. Then they enclosed the form in a hollow pillar of crystal, and placed it for 12 months in their houses. The process led to the story of preservation of dead in pillars of crystal.

Upon these ancient methods of embalming no marked improvements were made, as far as we know, until quite modern times, although there were great variations. The Guanches, who lived on the Canary Islands, washed the body for 4 days with water, annointed it afterwards with butter, and covered it with a powder composed of a dust of pine trees and brushwood, called "bressors," with pumice. Finally, they wrapped the body up in leather, and placed it in a cave. A specimen of a body preserved by this plan is in the museum of the Royal College of Surgeons.

Preservation of the dead by the simple process of drying, or desiccation, was practised by some communities. The Peruvians desiccated the bodies of their dead in sand. In Palermo, a monastery of Capuchin Friars suspended numbers of desiccated bodies of their fellows in galleries. Captain Smythe, who visited the monastery in 1624, reported that the bodies of 2000 had been so preserved in the building. A few years ago some bodies that had been long preserved by desiccation were exhibited in London.

In our modern days the process of desiccation has been very skilfully and practically applied for the temporary preservation of the dead. Falcony is the inventor of this plan, which consists in the temporary burial of the dead in a fine sawdust, charged with a salt which has a great affinity for water. Zinc sulphate is the salt that answers the purpose best. In cases where those who have died from infectious disease cannot be at once buried, Falcony's plan serves an all-important hygienic purpose. It is also most practical in instances where deceased persons have to be removed some distance for burial, or where other circumstances demand a delay in interment.

The Burman priests used for embalming purposes methods which varied but little from those of the Egyptians. They removed the contents of the abdomen, charged the cavity with spices, and covering the body with wax or rosin, finally gilded it.

In the monastery of St. Bernard, so well known to travellers, the bodies of dead persons who died in the mountains from cold were preserved by 2 natural processes, (*a*) extreme cold, and (*b*) slow loss of water—desiccation. These bodies are free of putrefactive changes, but they lose form and become shrunken from the loss of water.

If, now, we consider the lesson that has been taught by the embalmer's art, we learn that 3 distinct methods of preservation were thereby discovered—namely, preservation by the employment of antiseptic substances; by the plan of removing water—desiccation; by the action of cold. Up to the present day no new principle has been added to the art; it has been improved in its details, but on the same bases.

It was not until the time of the anatomist Ruysch, who was a contemporary of Peter the Great, that any important change of detail was introduced. Ruysch conceived the plan of injecting preservative fluids into the dead body by the blood vessels. The plan has been adopted for another purpose of late years, as if it were a new invention: it is not new at all. Ruysch carried the art of preserving by injection to such perfection that his specimens were the wonder of the time in which he lived.

William Hunter followed Ruysch in the plan of passing a preservative fluid into the dead body by the blood vessels. He injected by the arteries, selecting generally the large artery in the thigh, called the femoral, for the vessel into which to insert the nozzle of the syringe. His preservation of the body of the wife of the eccentric Martin Van Butchell was one of the curious events of the latter part of the eighteenth century. The embalmed remains of the lady are still retained in the museum of the Royal College of Surgeons, and prove that the embalmment, which was rather a prolonged and complicated affair, was successful in preventing putrefactive decomposition. The formula for Hunter's embalming solution is—1 pint Venice turpentine, 2 fl. oz. lavender oil, 2 fl. oz. rosemary oil, 5 pints turpentine oil.

When Dr. Richardson was making a visit to Paris in 1867, he was shown portions of a lady which had been preserved by some process which had never been revealed. From the general appearances he came to the conclusion that the secret preservative used in this case was nothing more than sulphuric acid, and he afterwards made some experiments of injecting the vessels of a dead animal with sulphuric acid slightly diluted, which showed him that the supposition was perfectly correct. The muscular structure in these instances seems as if it were partly charred, but it remains quite flexible, owing, probably, to an after absorption of water by the acid from the atmosphere. For the purpose of embalming, this process, as it now stands, is inapplicable; but if by any means the muscles preserved by it could have a fleshy colour communicated to them, it would be an invaluable method to the demonstrator of anatomy, since by its means he could preserve careful dissections of the natural parts for many years, ready at any moment for demonstration.

In 1854, Dr. Richardson made the observation that if liquid ammonia were brought into contact with dead animal structures, it would hold them for a long time in a state of perfect preservation. In this way, in a closed box, he preserved for a great many months numerous finely dissected specimens, and used them from session to session for purposes of demonstration. He also injected ammonia into the vessels of dead parts, in order to make it applicable as a preservative; but he does not think it would answer as a fluid for embalming so well as some other fluids, although for temporary preservation it leaves little to be desired.

Simple wood vinegar has been used by some embalmers for injection of the vessels. This application came from an observation made in 1833 by the distinguished chemist Berzelius, who examined a body that had been kept by this means in perfect preservation for 20 years.

At the time when Gannal's process was before the Academy of Medicine, Sucquet presented a preservative solution for embalming that was free of arsenic. It was a solution of zinc chloride. Experiments were made by the Academy with this solution, and with Gannal's aluminium sulphide and chloride solutions. Two bodies were embalmed, one by Sucquet's, the other by Gannal's process. The bodies were buried for 14 months, with favourable results.

The Brunetti method for the preservation of the dead consists of several processes: (1) The circulatory system is cleared thoroughly out by washing with cold water till it issues quite clear from the body, occupying 2 to 5 hours. (2) Alcohol is injected so as to abstract as much water as possible; occupies about ½ hour. (3) Ether is injected to abstract the fatty matters; occupies 2 to 10 hours. (4) A strong solution of tannin is injected; occupies for imbibition 2 to 10 hours. (5) The body is dried in a current of warm air passed over heated calcium chloride; may occupy 2 to 5 hours. The body is then perfectly preserved, and resists decay. The Italians are said to exhibit specimens which are as hard as stone, and retain the shape perfectly, and are equal to the best wax models.

At a meeting of the Philadelphia Academy of Natural Sciences, Prof. Barbeck described a number of preparations which showed beautifully the combined movements of the chest, larynx, and other parts engaged in the mechanism of breathing. Several snakes which had been treated with the fluid more than a year previously permitted of undulatory and spiral movements. Lungs thus prepared may, even after years, be inflated by means of bellows. Such old lungs were seen to swell to 10 times their size in the collapsed state, the lobes became distinct, the brown colour gradually changed into red, and the whole organ appeared as if taken from a fresh body. Sections of delicate tissues, morbid formations which have been removed by an operation, will appear after months as if in a fresh state, and may thus be preserved for future study.

All sorts of vegetable organisms may also be preserved in this fluid. A colony of exquisite fresh-water algæ, which had been in the fluid for a year, appeared to be growing in the water. The Prussian Government purchased this valuable discovery, and the Minister of Instruction published it in his official organ for the benefit of the scientific world. The formula for the preparation of the fluid is as follows: In 6½ pints boiling water, dissolve 3½ oz. alum, 6 dr. common salt, 3 dr. saltpetre, 1¾ oz. potash carbonate, 2½ dr. arsenious acid. After cooling and filtering, add to every 10 pints of the solution, 4 pints glycerine, and 1 pint methylic alcohol. The method of application differs according to the nature of the objects to be preserved. Anatomical preparations that are to be preserved dry are immersed in the fluid for 6 to 12 days, according to their size, then taken out and dried in the open air. Hollow organs, such as lungs, etc., must be filled with the preserving fluid, then laid in a vessel containing the same liquid, and afterwards distended with air, and dried. Small animals, such as crabs, beetles, lizards, frogs, etc., if the natural colours are to be preserved unchanged, are not dried, but put immediately into the preparation. The same fluid may be used for the purpose of preserving human bodies during transportation, or even for more permanent embalming.

Depérais proposed a process for disposing of dead bodies so as to guarantee the destruction of causes of infection without resorting to cremation. His process is based on the statement that at 223° F. (106° C.) all pernicious germs are destroyed. He utilises the well-known fact that saline solutions do not boil until after the boiling-point of water has been passed. The salt he employs is calcium chloride on account of its cheapness, the ease of its management, and because it is antiseptic and tanning in its effects. On plunging a corpse into such a solution at 96½° Tw. (47° B.) and slowly raising the temperature of the bath, it is evident that when the temperature passes 212° F. (100° C.) the water of the flesh and tissues will evaporate. Continuing the heat, the body contracts and the calcium chloride impregnates it. The prolonged bath kills the disease spores, and the hardening and antiseptic properties of the salt partially embalm the body; as, however, calcium chloride is deliquescent, the body would not dry on removal from the bath. It is removed by immersion in a bath of soda sulphate, by which the lime salt remaining in the body and incrusting all its fibres becomes lime sulphate, and sodium chloride is free in the bath. Then the body is dried either in the open air or in an oven.

If the object be not so much to embalm or preserve the whole body, as to preserve animal tissues or anatomical or histological specimens, so that they may be transported or shipped in any climate, and be in good condition for subsequent microscopic examination, the following method, communicated by Professor Welch, of Bellevue Hospital Medical College will answer :—

Portions of the organs should be cut into small pieces (on the average, cubes about 1 in. in diameter), and placed for 4 to 8 weeks in Müller's fluid. A large quantity of the fluid should be used, and it should be frequently changed for the first week, until it remains clear. After about 6 weeks the specimens are removed from the Müller's fluid, and for 3 or 4 days are thoroughly washed in frequently-changed water, until the water ceases to become yellow after standing some hours over the specimens. The specimens are then placed, either in alcohol or in a mixture of 2 parts alcohol and 1 water, and after a few days are ready for cutting for the microscope. The spinal cord is cut into pieces about ¾-in. long, which remain connected by the membranes, and can be hardened in the above manner, but should not, as a rule, remain longer than a month in the fluid. Small pieces can be hardened rapidly in strong alcohol. Here it is necessary to take pieces about ½–¾ in. in diameter, and to use a large quantity of strong alcohol. The chief errors are, not using a sufficiently large quantity of the hardening fluid, or in attempting to harden too large pieces. It is best to use at least 1 pint (and preferably more) of the Müller's fluid for 6 or 8 of the cubes 1 in. in diameter, and to change this fluid several times. The specimens should be obtained as freshly as possible from the autopsy. Well-stoppered glass vessels should be used for the hardening. After the specimens are once hardened by the process described, they can be preserved in a small quantity of alcohol, and can be sent packed in cotton-wool soaked in alcohol. The Müller's fluid alluded to is described below.

Of the solutions employed for preserving anatomical specimens, the best known are as follows :—

Babington's.—1 pint wood naphtha, 7 pints water.

Burnett's.—1 lb. zinc chloride, 1 gal. water ; immerse for 2–4 days, and then dry in the air.

Morell's.— 14 oz. arsenious acid, 7 oz. caustic soda, 20 fl. oz. water, and sufficient carbolic acid to produce opalescence when the mixture is stirred ; add water to make up to 100 fl. oz. Used for general disinfecting and embalming purposes.

Müller's.—2–2½ oz. potash bichromate, 1 oz. soda sulphate ; add water to make up to 100 fl. oz.

Passini's.—1 oz. mercury chloride, 2 oz. sodium chloride, 13 oz. glycerine, 113 fl. oz. distilled water.

Réboulet's. — 1 oz. saltpetre, 2 oz. alum, 4 oz. calcium chloride, in 16–20 fl. oz. water ; dilute according to need.

Seseman's.—Dr. Seseman states that a corpse may be made to retain the natural form of expression for months by (*a*) injecting into it a solution consisting of 4–5 per cent. of aluminium chloride dissolved in a mixture of 2 parts alcohol of 90 per cent. and 1 part glycerine ; (*b*) painting the entire epidermis with vaseline. The quantity of liquid required for injection is in the proportion of ⅒ to ⅐ of the weight of the corpse.

Thwaites'.—1 oz. spirit of wine saturated with creosote, rubbed up with chalk into a thin paste, and 16 oz. water gradually added.

Von Vetter's.—7 oz. glycerine at 36° Tw. (22° B.), 1 oz. raw brown sugar, and ½ oz. nitre ; immerse for some days.

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EMULSIFYING AND EMULSIONS.

To emulsify an oil consists in rendering it capable of mixing with water to form a uniform milky fluid, by the aid of an intervening medium, generally saccharine or mucilaginous.

Milk being the most perfect emulsion obtainable, the mixture of fat which simulates this compound most closely must likewise be regarded as superior in the degree that these qualities are intensified. To be sure, an artificial emulsion always represents a greater percentage of fat than milk, and its preservation is therefore relatively easier than in that obtained from nature, but this fact merely modifies the result, and does not involve the principle. The greater proportion of water in milk also favours decomposition, but on the other hand, the minute, perhaps even molecular division of the fat globules, renders it possible to withstand decomposition longer than an equally dilute artificial emulsion, wherein the oil globules are not so thoroughly disseminated.

We, of course, recognise the fact that milk contains different animal bodies not present in ordinary artificial emulsions, which are prone to decomposition, so that the similarity drawn between the two is based more upon physical characteristics than their presenting any features in common chemically.

But it is this attempt at compromising its principal physical feature —fluidity—with permanency, which makes the preparation of an emulsion so difficult. To so change a fat as to render it miscible with water is a matter of easy execution, but when we attempt to embody the desirable feature of fluidity, then we are thwarted by physical laws, and resort to chemical means as a compromise.

Condensed milk is a striking illustration wherein by a change of its physical condition, complete preservation has been attained much more satisfactorily than milk in its natural form could be preserved, even with chemical means. It is for this reason that *consistence* is the most desirable feature to ensure the permanence and preservation of any emulsion, natural or artificial.

It is well known that a perfect and permanent emulsion can be made with cod liver oil and malt extract, owing to the consistence of the preparation solely, as we have attempted to use the same agents represented in malt extract, namely—dextrine and glucose, and discovered that as soon as the consistence was abandoned these agents did not possess any advantage over those usually employed for emulsifying fats. To the albumen in milk has been ascribed the high degree of and most permanent emulsification, and therefore gelatine is employed in artificial emulsions, with not much better success however than other agents, when semi-fluid consistence is abandoned.

We will now consider what should be used as emulsifying agents and also such as, while largely used, are not desirable for obvious reasons.

Unfortunately the well-worn maxim, so justly applied to most classes of pharmaceutical preparations, "The sacrifice of medicinal value for elegance," has not been lost sight of in the preparation of emulsions. Periodically, different substances from all the different kingdoms of nature have been proposed, enjoyed a short, fashionable stay, and then been relegated to their well-merited oblivion.

The vegetable gums, acacia and tragacanth, have been the longest in use, and the first mentioned of these has probably answered the purpose of a reliable, convenient, and at least innocuous emulsifying agent better than the majority of latter-day substitutes.

The late Prof. Wm. Proctor announced the proportion to be used of gum acacia to produce a perfect temporary emulsion. His directions were as follows: "Mix intimately in a perfectly dry mortar the oil with one-half its weight of powdered acacia; to this add at once one-half as much water as the combined weight of oil and gum, and triturate briskly until the mixture has assumed the colour and consistence of a thick cream, which produces a crackling noise when the pestle is moved rapidly around the sides of the mortar." This is the emulsion proper, and to this can be added any amount more of water or other desirable vehicle or medicament to bring the finished preparation up to the quantity prescribed.

If perfectly made, this emulsion will stand any degree of dilution with watery mixtures; in fact, its quality is proved when, by a large addition of water, the oil globules will not separate or aggregate at the top of the liquid.

Practice has demonstrated that the proportion of gum can be varied according to the nature of the oil employed, but the constant relation between the water used for the emulsion proper, and the mixture of oil and gum must be scrupulously adhered to as ensuring infallible results.

Fixed oils, rich in gum, *per se*, as copaiba, castor-oil, etc., do not require as large an amount of gum as cod liver oil, while in the case of ethereal oils, for instance, oil of turpentine, an equal amount of gum, or weight for weight, is necessary. To prepare an emulsion from turpentine not unfrequently presents difficulties, and so much the more is this to be guarded against, as it is a powerful remedy, and, if presented in a merely mechanical mixture, will prove irritating, and perhaps engender serious consequences.

But then, if by careful observance of this method we can obtain a perfect emulsion, what more is desired? Although this emulsion is perfect, it is not permanent, and to circumvent this negative feature is the problem for solution.

While we have not discovered any means or process whereby this problem can be solved, yet we have found agents capable of preventing this separation in a great degree, being guided in their selection by a knowledge of the constituents which are most favourable to this separation, and those that are not.

An emulsion should be palatable, and for this reason it is always sought to make it sweet by the introduction of cane sugar or glycerine. These two agents are the cause of the most dissatisfaction with emulsions. Sugar, owing to its affinity for water, and density, favours separation very rapidly, precipitating while the emulsified oil forms a compact, creamy and gradually diminishing stratum at the top of the vessel. Glycerine, probably from the same causes and its incompatibility with fixed oils, behaves in a similar manner, and for these reasons these otherwise desirable vehicles cannot be represented in an emulsion when permanence is to be obtained.

As no other agents present themselves for fulfilling the sweet object in view, we have been in the habit of preparing emulsions without attempting to make them sweet, and, we believe, without detracting from their palatability, while enhancing their appearance.

Now, then, let us consider what agent will favour the homogeneity of the emulsion, that is, prevent separation or precipitation, bearing in mind that the preparation must not be changed physically or chemically.

Gelatine has been used with some satisfaction, as it retards the separation for a considerable length of time; in fact, it answers the purpose so well that for the extemporaneous preparing of emulsions it leaves nothing to be desired. But in common with other agents used for this purpose, it gradually loses its power of preserving the homogeneity of an emulsion, and eventually the separation and decomposition, so-called, alluded to above, take place.

The proportion of gelatine employed is about 40 gr. to 1 pint of the emulsion; it should be dissolved in the water and added at any time of the operation. By increasing this amount so that a jelly is formed of the emulsion, a perfectly permanent and stable preparation is obtained. But this result is obtained because the physical character of the emulsion has been changed—fluidity abandoned for consistence. Unhappily we cannot take advantage of this condition, and therefore "consistence is not a jewel" pharmaceutically.

Chemical agents such as change the character of an emulsion by saponifying the oil, have been largely advocated, and to the employment of this class of substances is principally due the elegance and permanence of ready-made emulsions. That this is attained at the sacrifice of the medicinal value of the preparation, we have no doubt, but medical authorities have also demonstrated it to be a questionable procedure to chemically change the constitution of a fat intended for internal administration by what should be a simple pharmaceutical process—emulsification, and now condemn the use of alkalies with balsams and resins. Copaiba is no more exhibited with solution of potash, and alkalies are generally conceded as operating to break up the sensitive electro-negative principles of resins, upon which their medicinal value chiefly depends. Animal fat, and especially cod liver oil when rendered alkaline, undoubtedly suffers decomposition in those very constituents to which its superior digestibility is due, and thus what has been gained on one hand is more than lost on the other. The saponification which has been produced by the use of the alkali renders the preparation very prone to rancidity if exposed to the air, and even when freshly made, it possesses inferior palatability, but then this has been of secondary importance to homogeneity or elegant appearance.

But our materia medica is vast in extent, and we have yet another quarter to draw upon, namely, the animal kingdom. It was a rational thought which prompted the employment of egg-yolk as an emulsifying agent, and how well it answers the purpose, we are all familiar with. Egg-yolk unfortunately does not belong to the general armament of a pharmacy, and a convenient and stable form thereof was therefore suggested in the preparation *glyconin*, a mixture of egg-yolk and glycerine in about equal proportions. Although the proportion of glyconin required for emulsifying oil is small, about 1 to 4, and therefore the quantity of glycerine in the finished emulsion not very great, we prefer to use the fresh yolk alone when this can be obtained.

Egg-yolk sometimes possesses advantages as an emulsifying agent over gum acacia when this latter is inadmissible on account of the precipitation that would take place when alcoholic liquids are desired in the combination. The following prescription is typical of the class of preparations in which it will prove a valuable agent :—

EMULSION OF COPAIBA AND SPIRIT NITROUS ETHER.

Take of

Copaiba	2 oz.
Oil Almonds, Exp. . . .	4 ,,
Oils, Gaulther. and Sassafras, each	20 m.
Egg-yolk (or Glyconin, 3).	1½ oz.
Water	4 ,,
Turpentine pitch . . .	1 ,,
Spirit Nitrous Ether . .	4 ,,

Make an emulsion as described under gum acacia. Dissolve the turpentine in the spirit of nitrous ether, and add it to the emulsion.

But it has been reserved unto physiological chemistry to discover upon the whole the most rational and valuable of all emulsifying agents. Not valuable in the sense that the preparations are either permanent or homogeneous, but valuable because the emulsification is the most natural and attained with the least change only in so far as its superior assimilative qualities are concerned. That preference should be given to such agent in preparing an artificial emulsion as fulfils this mission in the animal or human body we cannot deny, providing it is capable of practical application; that is, if this agent can be obtained in as natural a form as necessary to serve this same purpose artificially. Pancreatine, as is well known, is that peculiar principle which is secreted by the pancreatic gland in animals, performing the function of emulsifying fats so as to prepare them for assimilation in the economy. Modern therapeutists, reasoning that maladies such as indigestion or malassimilation of food, especially of a fatty character, would be benefited by this agent supplied artificially, have had their expectations realised in no small degree, and pancreatine has therefore met with increasing favour. Although believed to be a complex substance, and to possess digestive powers identical with those of pepsine and ptyaline, yet it seems undoubtedly to exercise power on fats, decomposing them in glycerine and fatty acids, thus fitting them for ready absorption.

Pancreatine has been largely prescribed in substance, but of this we have nothing to say, as our observations are in regard to its pharmaceutical use. The pancreatine obtained from the fresh pancreas of the calf, vulgarly termed sweetbreads, has been most successful in our hands, and we feel confident that as an emulsifying agent it will be found superior to that obtained from the hog or sheep.

Pancreatine possesses greater emulsifying power than any agent we are acquainted with, 1 gr. of this article prepared by the writer having been found sufficient to emulsify 1 oz. of cod liver oil; and by careful manipulation, after having been rendered slightly alkaline by soda, as much as 3 oz. were emulsified, or over 1200 times its weight. An emulsion of this strength is, however, not permanent, and requires the addition of some heavier emulsifying agent in reduced proportion. A pancreatic emulsion, owing probably to its partially decomposed condition, while a desideratum from a therapeutic stand-point, is not so pharmaceutically, unless prepared within a reasonable period of the time when wanted for administration.

As an illustration we now submit a formula for a somewhat largely used preparation originating in the Bellevue Medical College Hospital, New York:—

PANCREATIC EMULSION OF COD LIVER OIL AND HYPOPHOSPHITES.

Take of

Cod Liver Oil	8 oz.
Oil Gaultheria	15 m.
Oil Bitter Almonds . .	10 ,,
Gum Acacia	2 oz.
Pancreatine, 90 per cent. .	15 gr.
Pepsin, U.S.	60 ,,
Calcium Hypophos. . . .	60 ,,
Sodium Hypophos. . . .	60 ,,
Water	5 oz.
Spirit Frumenti	1½ ,,

Mix the oils and gum acacia, dissolve the hypophosphites, pepsin, and pancreatine in the water, make an emulsion to which add the spirit frumenti.

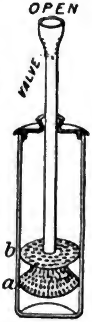

FIG. 77

In conclusion we call attention to a simple apparatus for making emulsions in a larger way than can be done economically in a mortar.

Fig. 77 shows an ordinary vessel in which sets a narrow tin cylinder with a valve at the top, fastened with a hinge, a bell-shaped and perforated terminus being attached to the lower end *a*, immediately above which is also a wooden diaphragm *b*. The mixture to be emulsified must half fill the vessel, and by working the cylinder perpendicularly the air, being confined by the valve closing at the top when the cylinder is plunged downward, is forced all through the mixture, and a perfect emulsion is formed in a very short time. (C. S. Hallberg.)

The successful formation of emulsions, whether of fixed or volatile oils, is dependent upon certain rules, well understood by accomplished pharmacists, which when deviated from will invariably embarrass the operator, either by retarding or completely preventing perfect emulsification. These rules are :—

1. That the water and gum arabic * shall be in definite and absolute proportion to each other. This proportion is 3 parts of water to 2 of gum, both by weight.

2. That the relation of oil to gum (and water) shall be definite within certain limits ; that is to say, the mucilage formed in the above proportions is capable of perfectly emulsifying a minimum and a maximum proportion of oil. The minimum proportion is 2 parts of oil to 1 of gum ; the maximum proportion is 4 of oil to 1 of gum.

3. That the trituration of the oil, gum and water be continued until a perfect homogeneous, milky white, thick creamy mixture is formed, i.e. until perfect emulsification takes place, before the addition of a further quantity of water or other liquid.

The thick creamy emulsion obtained, if the above conditions are fulfilled, must be the basis of all perfect emulsions. It will bear dilution to any extent with water, forming mixtures varying, according to the proportion added, from the appearance and consistence of cream to that of very thin milk. Obviously the water may be replaced by solutions of saline compounds, syrups, etc., and this permits the production of the various combinations of cod liver oil in current use from the above thick creamy emulsion, which for distinction may be designated as—

I. *Concentrated Emulsion of Cod Liver Oil.*—Take of fresh Norwegian cod liver oil, 3 oz. ; powdered gum arabic, 2 oz. ; distilled water, 3 oz. First weigh the gum into a wedgwood or porcelain mortar, then the oil, and triturate till the gum is well mixed with the oil ; then weigh into the mixture the distilled water, and triturate the whole briskly until the mixture thickens and acquires a pasty consistence and milky whiteness. Now scrape down the portions adhering to the sides of the mortar and to the pestle, and continue the trituration for a short time, after which add such other ingredients as may be desirable, or transfer the concentrated emulsion to a wide-mouthed bottle for future use.

This concentrated emulsion will keep for a reasonable time in cold weather, and, if placed in the ice chest, also during warm weather. It may, therefore, be kept in stock, if the demand for emulsions is brisk enough to justify it ; but inasmuch as its preparation does not consume more than 5 or 10 minutes, it is advised to always prepare it fresh, or at all events, never to prepare more than a week's supply, particularly in summer. Its consistence is such that it is poured out of the containing vessel with difficulty ; hence the necessity of using one with a wide mouth, which should be as securely stoppered as possible, and should be cleaned very carefully each time it is refilled. All this takes time and involves trouble, which is prevented by preparing the concentrated emulsion only as required.

II. *Simple Emulsion of Cod Liver Oil.*—Take of concentrated emulsion of cod liver oil, 13 oz. ; oil of wintergreen, 24 drops ; syrup, 1 fl. oz. ; water, 3 fl. oz. Weigh the concentrated emulsion into a mortar, add the oil of wintergreen, and triturate thoroughly ; then gradually add first the water and then the syrup.

The manipulation for this emulsion is typical for all the other cod liver oil emulsions given below. It has the consistence of very thick cream, but is readily poured out of narrow-mouthed bottles, is milky white, and mixes readily with water or other liquids that may be administered with it. It contains exactly 50 per cent. (by volume) of oil, the quantity that manufactured emulsions are said to contain, although some of them do not contain that proportion. The oil of wintergreen disguises the odour of the cod liver oil admirably, and has the further advantage that it acts as a preservative.

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* The writer is well aware that other emulsifying agents have been proposed and are used, but he is satisfied that none of these answers as well as does gum arabic.

III. *Emulsion of Cod Liver Oil with Hypophosphite of Lime.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite are dissolved in the water, each tablespoonful of the finished emulsion containing 4 gr. of that salt.

IV. *Emulsion of Cod Liver Oil with Hypophosphite of Lime and Soda.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite and 96 gr. of sodium hypophosphite are dissolved in the water, each tablespoonful of the finished emulsion containing 4 gr. of the calcium and 3 gr. of the sodium salt.

V. *Emulsion of Cod Liver Oil with Hypophosphites.*—This differs from the simple emulsion in that 128 gr. of calcium hypophosphite, 96 gr. of sodium hypophosphite, and 64 gr. of potassium hypophosphite are dissolved in the water; each tablespoonful containing 4 gr. of the calcium, 3 gr. of the sodium, and 2 gr. of the potassium salt, and corresponding to a teaspoonful of Churchill's syrup of the hypophosphites.

VI. *Emulsion of Cod Liver Oil with Phosphate of Lime.*—This differs from the simple emulsion in that 256 gr. of calcium phosphate are dissolved in the water by the aid of 128 gr. of hydrochloric acid,* each tablespoonful containing 8 gr. of the phosphate held in pleasantly acid solution.

VII. *Emulsion of Cod Liver Oil with Phosphate of Lime and Soda.*—This differs from the simple emulsion in that 256 gr. of calcium phosphate and 64 gr. of sodium phosphate are dissolved in the water acidulated with 128 gr. of hydrochloric acid; each tablespoonful containing 8 gr. of the calcium and 2 gr. of the sodium salt.

VIII. *Emulsion of Cod Liver Oil with Lactophosphate of Lime.*—This differs from the simple emulsion in that 256 gr. of calcium lactate dissolved in 2 fl. oz. of diluted phosphoric acid are substituted for 2 fl. oz. of the water, each tablespoonful containing 8 gr. of lime lactate or about 13 gr. of lactophosphate.

IX. *Emulsion of Cod Liver Oil with Wild Cherry Bark.*—This differs from the simple emulsion in that the oil of wintergreen is replaced by 8 drops of oil of bitter almonds and in that 1 fl. oz. of the fluid extract of wild cherry bark is substituted for 1 fl. oz. of the water; each tablespoonful containing 15 minims of the fluid extract and one-fourth of a drop of oil of bitter almonds.

Other combinations of cod liver oil with different medicinal agents may be effected in the same way as pointed out in the above, or the proportions of salts may be varied to suit particular cases. The process for the concentrated emulsion also may be applied to the emulsification of other oils, as, for instance, in the following:—

X. *Emulsion of Castor Oil.*—Take of castor oil, 4 oz.; powdered gum arabic, 1 oz.; distilled water, 1½ oz.; syrup, cinnamon water, of each 3 fl. oz.; spirit of cinnamon, 12 minims. Emulsify the oil with the gum and distilled water as directed under I., then add the other ingredients successively with constant trituration. This emulsion contains 33 per cent. of castor-oil, and is consequently more limpid than the 50 per cent. cod liver oil emulsions above described, and is in every respect an elegant preparation. (C. Lewis Diehl.)

Photographic Emulsions.—A useful contrivance for making photographers' emulsions is shown in Fig. 78: *a*, funnel with tuft of cotton wool in its throat, serving to filter the inflowing water; *b*, guttapercha bung; *c*, jampot provided with a hole to carry a cork, holding an indiarubber tube *d*; *c*, muslin bag retained in position by the bung, and containing the fragments of emulsion.

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* The use of hydrochloric acid instead of phosphoric acid is preferred, because the large quantity of the latter required would make the preparation unpleasantly sour.

Another excellent apparatus for making gelatine emulsions for photographic purposes is that introduced by Birrell, and illustrated in Fig. 79.

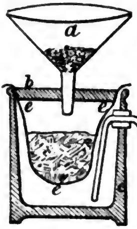

FIG. 78

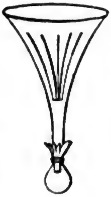

FIG. 79.

This apparatus is placed under a tap, the water being allowed to flow in at about the same rate as it will flow through the filtering medium in the funnel. Instead, however, of using cotton-wool for the purpose of filtering the inflow water, it is more convenient to tie a piece of muslin over the stem of the funnel as shown in the subjoined diagram, this method of arranging a filter having been recommended by Colonel Dawson in another case. All string and muslin used should be cleansed before use by boiling in soda and subsequent washing, as recommended in respect to the canvas; and it is undesirable to use either of such materials a second time when one is making a highly sensitive emulsion. The washing being completed, the muslin strainer is removed from the jar, and, the edges being gathered together, the whole is swung round a few times to drive off the loosely held water; but, notwithstanding this, it is extremely probable that the fine shreds of emulsion will have absorbed so much water as to make the preparation inconveniently weak when melted, and the test of this is to weigh the product. A clean beaker of suitable size is balanced on the scale-pan, and a piece of wet muslin corresponding to that used for retaining the emulsion is placed in the weight-pan. The square of muslin containing the emulsion should now be tied up blue-bag fashion, placed in the beaker, and weighed. If it weighs more than 750 grm. (26½ oz.), it is well to remove some of the water—a very easy matter, if the bag be dipped in alcohol—and moved about for a few minutes, after which it is once more swung round to drive off the redundant water and again weighed.

ENAMELLING FOR ARTISTIC AND COMMERCIAL PURPOSES.

(*See also* GLASS.)

THE first part of this article consists of matter extracted from a series of highly instructive Cantor Lectures on Art Enamelling read by H. H. Cunynghame, before the Royal Society of Arts, and reprinted by permission.

It has been found that several metals, among which are gold, silver, iron, copper, and fine bronze—that is to say, copper with a small admixture of tin—are capable of being covered with glass, fused on to them by means of heat. But to other metals, such as nickel, or zinc, or brass—which is a mixture of copper and zinc—the glass will not adhere. The usual method of applying the glass is to reduce it to fine powder, to spread it over the metal in a thin layer, and then to put the metal into a furnace raised to a red heat, until the glass melts.

Colouring Agents.—*Black Sesquioxide of Cobalt* (Co_2O_3). This, when united with silica and potash, forms the blue glass known as smalt blue. The oxide when pure is a very powerful colouring agent. Even one part in a thousand of glass gives a fine royal blue. The ore of cobalt is called "saffre," from which the word sapphire is derived. It contains a large quantity of arsenic, which makes the operation of roasting it dangerous. In consequence the German miners called it after the "kobolds," or spirits of the mines. Saffre contains about half its bulk of black oxide. The colour of cobalt is brightened by the addition of some alumina (i.e. oxide of aluminium or clay). It is darkened by the addition of iron manganese or uranium. Phosphate of cobalt can also be employed. One and a half parts of phosphate are equivalent to one of oxide of cobalt.

Black Oxide of Copper (cupric oxide, CuO) is the scale formed on copper when heated to redness in the air. It colours glass a light sea-green. With soda glass its colour is more blue than with potash glass, and varies with the degree of heat at which it is melted. Greater heat produces a more green tinge. About 2 per cent. of it gives a fine sea-green. It may simply be added in powder to a crucible full of melted glass. It is a treacherous colour, as it tends to make the enamel brittle. Another plan is to employ nitrate of copper by dissolving, say, 10 grm. of copper in nitric acid, then add 20 grm. of anhydrous carbonate of soda, or a corresponding proportion of ordinary carbonate. The mixture will strongly effervesce; when the effervescence has ceased enough nitric acid should be added to convert all the soda into nitrate of soda. Make it up to 200 c.c. in bulk, and wet with it from 700 to 1000 grm. of powdered dense flint glass; dry it and melt. It gives a fine, somewhat greenish turquoise. The nitrate of soda serves to prevent the lead from being reduced.

Red Oxide or Suboxide of Copper (Cu_2O) is used to give a red colour, either transparent or opaque, to glass, but is not employed by the enamel-maker, because gold serves the same purpose much better. (See farther on, under the heading "Gold.") When black oxide of copper is added in larger quantity, as say 6 per cent., and then, when melted, some iron filings are added and slowly cooled, we obtain the sparkling mass known as "aventurine." The colour of copper enamel can be modulated by the addition of oxide of zinc, oxide of cobalt, oxide of chromium, or oxide of uranium.

The Oxide of Iron most usually employed is the red peroxide or ferric oxide (Fe_2O_3) known as rouge or crocus martis. It dissolves with some difficulty in silica. When 5 per cent. of this is *dissolved* in glass it gives a sickly green colour like bile. If simply mixed into the melted glass in large quantity, say

20 per cent., so that it is not dissolved, it affords a red opaque enamel like red sealing-wax, which is useful for many purposes. Rouge is generally made by calcining sulphate of iron. The red oxide of iron used as medicine is obtained by precipitating a salt of iron with ammonia. So that for making opaque red, rouge is preferable; but for dissolving and making green, the precipitated red oxide of the druggists is the best.

A fine green may be made of a union of precipitated iron peroxide and chromate of potash, but the shorter way is to procure chromate of iron, of which there are two sorts, the dark and the light, which both serve equally well.

About 3 per cent. of chromate of iron gives to enamel a fine bottle-green colour, the shades of which can be modulated by the addition of copper, cobalt, and uranium.

Black Binoxide of Manganese (MnO_2) gives a reddish purple. About 4 per cent. is a useful proportion. When in the crucible, oxygen is disengaged, which causes the ingredients to foam up; hence the crucible should only be filled one-third full at first, and the rest added gradually. Manganese is called in German "brown-stone;" and by the French, "peridot," after a town near Limoges, whereit was found. It is not easy to get good oxide quite free from iron.

When manganese is melted up without any oxidising agent being present, or when it is long heated, especially when it contains a little iron, it takes a reddish tone. The violet hue is obtained only when the manganese is kept well oxidised with nitrate of potash.

Mixed with rouge, manganese forms a fine warm reddish brown, and is the only sort of transparent red which the old masters possessed, at least till gold-red was discovered, the date and introduction of which seem a mystery.

Manganese gives with cobalt a bluish violet, and with cobalt, iron, and copper it gives a deep black.

Instead of using this oxide of manganese, we may employ one and a half times the amount of permanganate of potash, which may be dissolved in water, and the powdered flux wetted with it, and then dried. This gives a very fine colour, and I think it is preferable to using the oxide, for it is much more pure.

Some sorts of binoxide of manganese are black, some brown, but their quality is the same. It is a difficult pigment to get pure, and for fine colour purity is desirable.

Yellow (so-called) *Sesquioxide of Uranium*, or what is really uranate of soda, is a most useful colour. Its only drawback is that its colouring power is feeble. It takes 15 per cent. to make a full yellow. It mixes well with copper and chromium to form brilliant greens, and with gold it forms a splendid orange colour, but its use requires some precautions.

If simply mixed with powdered dense flint, with the usual 2 per cent. of potash, it gives a bottle-green, which, after many hours of heating, becomes at last a dirty yellow.

In order to get the canary colour out of uranium, it seems necessary to keep it reduced. and therefore the best way of making it is to heat together some ordinary flint glass, such as Chance's potash flint, 10 per cent. of minium, from 10 to 15 per cent. of uranium, and 2 per cent. of potash. This in about an hour gives a fine yellow.

It is important to get good uranium. The brand known as "Joachims-thal" is the best. It is of a fine deep yellow, almost an orange, and can be got from the vendors of chemicals for china manufacturers.

Chromium.—If employed in the form of the green sesquioxide (Cr_2O_3), it gives a fine opaque green. This is due to the fact that the sesquioxide dissolves in glass only with great difficulty. And most of it therefore remains suspended. If, however, yellow bichromate of potash is used ($K_2Cr_2O_7$), it is all dissolved and gives a bilious green. When a large quantity, such as 8 per cent., is used, the glass becomes surcharged, and the chromium crystallises out, producing green aventurine.

But chromium is best used for greens in combination with iron, as above described.

Nickel is a valuable colouring agent. Carbonate of nickel ($NiCO_3$), a green powder, imparts to the glass a fine cold sepia brown; from 2 to 3 per cent. may be employed.

Gold.—Great mystery has been made as to the production of crimson from gold, and all sorts of accounts are given in the books of its manufacture. In some the tedious process of making purple of Cassius is recommended, which I will not detail here as it is of no use to the enameller. I do not, however, know any book in which a sufficiently detailed method is described to enable the workman to succeed with certainty. The one I give will therefore be the more valuable because I have tried it so many times as to be certain of its success. To make the gold-red it is essential that some raw minium should be present. Hence then it will not do to begin with dense flint. We must begin with a light flint. Ordinary powdered light flint serves admirably for the purpose, but it should be a soda flint, or heavy soda flint can also be employed.

Soak a kilogramme of it in 300 c.c. of water, in which 1 grm. of chloride of gold has been dissolved; mix well. The ordinary chloride used for photography does very well. Add 250 grm. of minium, and 100 grm. of yellow uranate of soda, or, as it is usually termed in trade, "orange oxide of uranium." Add also 20 grm. of nitrate of potash in powder. Put these all in a basin and mix them well and evaporate till they are dry. Then triturate them all together in a large mortar till they are perfectly mixed.

Heat a crucible in the furnace till it is of a bright red, and then fill it with the powder. Put on the lid and get up a sharp heat for half an hour. The mixture first turns a light opaque pinkish-brown, then in about 15 minutes it fuses into a clear canary yellow, which deepens during the next 15 minutes. It may be stirred once, but stirring is apt to cause the lead to be reduced, and if the preliminary mixing has been well done it is not necessary. Then take out a specimen on the tip of a rod, let it cool and reheat it. If on heating it appears orange, the operation is near completion, but the heat must be continued till in about 35 to 40 minutes on reheating the glass becomes of a blood red. The contents of the crucible may now be poured, and will be of a bright full canary yellow. The pieces may be used in this way, and will turn red on firing, or else bits may be held in the tongs in the muffle furnace till the colour comes, or put on bits of platinum and reheated.

But the critical moment must not be lost, for if the operation be continued too long, the glass becomes of a light-brown semi-opaque tint, and it is then almost impossible to get it back again. The tint will be fire-red.

Instead of the uranium, 2 per cent. of black protoxide of tin or stannous oxide (SnO) may be added. In this case the colour, instead of being a fire-red, will be of a more purple tone. A much longer period of heating is however required.

These two colours are most valuable for enamelling.

It may be a matter of some surprise that so short a heating produces the result. It seems, however, true that, though alkalis take a long time to unite with silica, lead is soon and easily dissolved in glass.

I have done many enamels with gold made as above described. They are very brilliant, and have never split. On the contrary, they seem remarkably elastic and stable.

The reader must also be cautioned against statements in several manuals such as that gold-red cannot be made with glass containing lead, or again, that it cannot be made except with glass containing lead, or again that it cannot be made except with borax. All these statements are false. In fact, it is possible to make gold-red almost anyhow, if only the exact proportion of the ingredients is hit off. And these exact proportions seem in each case to be a matter of experiment.

About ·05 per cent. of black oxide of cobalt added to the gold and tin will give the red a violet hue, but so like that of manganese as not to present any particular advantage over enamel made with manganese.

On white these reds made with gold give a fair effect, but their chief use is upon gold paillons, when they give a glorious colour. Iron can also be employed as what I may call a precipitant, but its effect is not so uniform. In fact, nothing equals uranium. It acts best when about 15 per cent. is put in, and the resulting glass is beautifully smooth and workable.

Copper may also be used to give a deep red colour with the use of tin. But at least 5 per cent. of red oxide of copper is required, otherwise the glass becomes transparent green. The colour comes, like that of gold, upon reheating. The large amount of copper required makes the enamel too deep for use. It is asserted that some German firms have succeeded in making thinly-tinted red glass with copper oxide. As a rule, however, it is only used for "flashing" glass, that is to say, in a very thin layer on the surface of transparent glass.

In the middle ages, copper was much used in this manner.

During the French Revolution a large number of the finest church windows in France were destroyed in the belief that the red glass was rich in gold, but the chemists having shown that it was made with copper, the work of destruction was stayed.

If a very large proportion of red oxide is put in, and the heat not made too great, the red oxide is melted into and suspended in the glass, and a rich, crimson, opaque enamel is obtained.

Tungsten can also be employed to strike down the red colour in copper and gold, but it seems to possess no particular advantages.

I may add that the above suggested theory of metallic precipitation, akin to the sort of action that goes on in the development of platinotype prints, is a mere hypothesis, for at present the chemistry of the coloration of glass with gold and copper is not understood.

Iridium Oxide is an intensely black powder. It colours glass most powerfully; ·03 per cent. of it gives a good grey. But its greatest use is, when mechanically mixed with 2 to 4 parts of flux, as an opaque black pigment. It serves then the same purpose as Indian ink does on paper.

Selenium is a black, brittle substance, somewhat akin to sulphur. If pounded up and mixed intimately with pounded glass and about 2 per cent. of nitrate of potash, it gives a fine yellow colour. But when a reducing agent is present it gives a rose colour.

Opaque White is made by melting white oxide of tin (stannic acid) with powdered glass. The tin is not dissolved in the glass, but suspended in it like a pigment. But the tin has so strong a reducing power that, if a mixture of powdered dense flint glass and oxide of tin were melted together, the lead would become reduced and the mixture blackened. The tin must therefore be introduced by an artifice. This can be done by taking light flint and mixing it with sufficient minium to change it into dense flint, and at the same time introducing the tin, for the minium keeps the mixture oxidised; a little nitrate of potash might also be added for the same purpose. Thus if we take of powdered flint, 6 parts; minium, 1 part; white stannic acid, 2 parts; we shall get a white very well adapted for grisaille. It will be so hard as to be almost impossible to pour, and must be dragged out of the crucible. But it is a splendid material for use of grisaille. It is, however, almost too hard and devoid of polish, and if employed for doing grisaille, must be glazed over with flux when finished. To soften it is an easy matter by introducing some borax. This will bring it down to any refined degree of fusibility, till it is soft enough to be useful for enamelling watch faces, or any other similar purpose. The lead and tin may also, at least in part, be introduced into the enamel in the form of "putty powder."

Without the use of some borax it is almost impossible to get a fusible and yet brilliant white.

Nothing but a very hard white is of use for doing grisaille. Messrs. Emery, the colour makers, make an excellent white, known as No. 100, for use by china painters, which I can recommend strongly for grisaille, as it stands the fire well in the half-tones.

Grass Green.—Melt powdered flint glass with 3 per cent. of chromate of iron, and 2 per cent. of nitrate of potash. Or, mix powdered flint glass with 1·6 per cent. of black oxide of copper, ·8 per cent. of bichromate of potash, and 2 per cent. of nitrate of potash.

Dark Rifle Green.—The usual quantity of nitrate of potash, and from 10 to 20 per cent. of nitrate of copper.

Turquoise.—This must be made with soda glass, for potash glass produces a bluish green like a faded turquoise. In a crucible of melted glass stir 1¼ per cent. of black oxide of copper: it will dissolve easily. Or 2 per cent. of nitrate of copper in powdered crystals may be used.

A Pale Sky Blue.—Powdered flint with 2 per cent. of nitrate of potash, and ·2 per cent. of fluor-spar.

Iron Blue.—To the materials for turquoise, add ·025 up to ·05 per cent. of black oxide of cobalt.

A Deep Royal Blue.—Powdered flint glass with the usual quantity of nitrate of potash, and 2 per cent. of black oxide of cobalt.

A Medium Royal Blue.—The same, but with ·6 per cent. of oxide of cobalt.

A Light Royal Blue.—The same, but with 12 per cent. of oxide of cobalt.

All the above may be toned to a more sober hue by the admixture of a little iron. The modern blues are rather brighter than the ancient, because the cobalt now obtainable is purer. Instead of iron, if about 5 per cent. of yellow oxide of uranium is introduced, the same effect will be produced.

Black.—Cobalt, 3 per cent.; manganese, 2 per cent.; brown chromate of iron, 2 per cent.

Antique Red.—Manganese, 2 per cent.; rouge, 2 per cent.; nitrate of potash, 2 per cent.

Purple.—Permanganate of potash, 4 per cent. to 8 per cent; nitrate of potash, 2 per cent.; or binoxide of manganese, from 3 per cent. to 6 per cent.

The permanganate may be simply stirred into a crucible of molten glass, in which case no nitrate of potash need be employed, but it requires a good stirring to disseminate the colour throughout the glass.

Brown.—1 per cent. of green carbonate of nickel; 2 per cent. of nitrate of potash.

Dove-coloured Grey.—1·3 per cent. of black oxide of manganese; ·05 per cent. of bichloride of platinum in crystals.

Slate Grey.—Bichloride of platinum, ·05 per cent.; nitrate of potash, 2 per cent.

Fire Ruby (*see* GOLD, above).

Ruby (*Blood Colour*).—Made as before described; ·1 per cent. of chloride of gold, 2 per cent. of protoxide of tin, and 2 per cent. of potash.

Claret Colour.—As for ruby, but with the addition of ·05 per cent. of cobalt. And note here that when such small quantities of colouring matter are to be added it is best done by adding the requisite amount of powdered glass coloured with cobalt, or whatever else it may be wished to add.

Canary Yellow.—15 per cent. of

uranate of soda; 2 per cent. of nitrate of potash.

A Fine Orange Yellow.—4 per cent. of metallic selenium; 2 per cent. of nitrate of potash.

The selenium must be very finely powdered, and then with the potash well incorporated with the pounded glass; for selenium, like sulphur, is very volatile.

Testing Enamels.—After making each batch of enamel it should be tried. This is best done by preparing a copper label bulged like a plaque, and with a hole in it, and of dimensions say 1 in. by 2 in. This should be covered with any common white and fired, and then with a pretty thick coating of the colour and fired. While it is just so hot that it can be touched, it should be put under a tap of cold water, and if does not crack it may be pronounced sound. Its composition should then be indicated on a gummed label pasted on the back, and the whole used as a label to the jar containing the enamel. It thus serves as a colour index, a record of composition, and a test of the resistance and durability of the enamel. A bad enamel will generally crack in the course of a month after it is made, but I never knew one to go in this way that had stood the water test.

Framing Enamels.—Very handsome frames may be made for enamels out of pure nickel, which can be obtained in sheets. It is capable of being soldered with hard solder, and a frame of nickel covered with ornamentation of burnished gold is very beautiful. The fire only gives it a sort of dull patina, which is very fine, and by the use of acids can be made almost any colour you like. If on the nickel you paint figures with gold powder mixed with gum water and a little borax, and fire them well in the furnace, and put on more gold and fire again once or twice, and then burnish the gold with a hematite burnisher, a very beautiful effect is obtained, like the Indian gold-inlaid work. The gold adheres well, and is difficult to get off except with a scraper. Nickel is capable of producing all the effects of silver, and in addition does not tarnish. But it will not take enamel, for it gives rise to bubbles and the work comes off.

Enamelling Iron.—(*a*) In enamelling metals, the enamel is fused by heat upon the surface of the object, and is incorporated by fusion with its surface. Enamel for metals must therefore be indestructible by heat. There are two kinds of enamel, the transparent and opaque; the first is the base of all the coloured enamels, which are produced by adding some metallic oxide to this transparent flux. The transparent enamel is produced by fusing the following materials, which are first ground, then dried, fused, and again ground for use: 3 parts silicious sand, 1 chalk, 3 calcined borax; or, 3 parts broken crystal glass, 1 calcined borax, ¼ nitre, 1 diaphoretic antimony (well washed). Dead white enamel, or calcine, is produced by calcining 2 parts zinc and 1 of lead together. The calcine, or combined oxides, is mixed up with crystal and manganese in the proportion of 1 part combined oxides or calcine, 2 fine crystal (glass) powder, 40 manganese. These are ground together and fused; when fusion is completed, the vitreous mass is poured into water, ground, and fused anew, and this operation is repeated several times, and much care must be exercised, for the smallest portion of oxide of copper will spoil the enamel completely. Other colours are obtained by adding to the transparent ground enamel the following materials, according to the colour desired: Blue enamel, by adding oxide of cobalt or some of its combinations, with the addition of a little nitre. Black enamel, by peroxide of manganese or iron and a little cobalt. Clay produces, with about ¼ protoxide of iron, a fine black enamel (clovet). Yellow enamel, by phosphate or sulphate, or some preparation of silver, or oxide of lead and antimony. Thus, 1 part white oxide of antimony, 2 to 3 white lead, 1 alum, 1 sal-ammoniac. Green enamel is obtained directly from oxide of copper or oxide of chromium. Red enamel is more difficult to secure than many others. The protoxide of copper is used in a hydrogen or carbonaceous flame, so as to keep the copper from peroxidising, or the preparations of gold, e.g. the purple of Cassius. Violet enamel, by adding peroxide of manganese and a little nitre, any shade of violet to amethystine colour, or even black, can be obtained. Enamelling is performed in an oven or by lamp. ('Building News.')

(*b*) To enamel iron it is the best plan to make a flux to fuse at a moderate heat, and this, being fused over the metal, makes a good surface for the white or coloured enamels to work upon.

Such a flux is made by 20 parts flint glass, 20 parts white lead, 2 parts whiting, and 2 parts ball clay. These materials must be finely ground and well mixed, then they are fired in a fire-clay crucible, rather sharply, for about five or six hours, or until the materials all run down into a liquid. When this is effected, take the crucible from the kiln, by a pair of tongs, and pour the liquid flux direct into cold water. After this, grind the material to a fine powder and it is ready for use. It may be mentioned that some enamels do not require grinding to a fine powder but this flux should be ground very fine. To use the flux first brush over the metal with a little gum solution then powder the flux over it. Fire until the heat is sufficient to fuse the flux.

After the metal is coated with fused flux any of the following enamels may be used, either powdered direct on, or powdered on to a thin coat of gum. Or the enamel mixtures may be mixed with oil and the metal articles dipped in it. Fire the enamels until they run bright.

The following enamels are what are termed "soft." All parts are by weight.

White.—32 parts flint glass, 3 parts oxide of tin, 3 parts nitre, 8 parts red lead, 2 parts flint or china clay.

Black.—3 parts red oxide of iron. 3 parts carbonate of cobalt, 12 parts red lead, 4 parts borax, 4 parts Lynn sand.

Yellow Coral.—2 parts flint, 5½ parts red lead, 2 parts chromate of lead, ½ part borax.

Coral Red.—2 parts flint glass, 3 parts flint, 3 parts sugar of lead, 9 parts red lead, 2 parts bichromate of potash.

Canary.—2 parts flint glass, 3 parts flint, 9 parts red lead, 2 parts oxide of uranium.

Turquoise.—24 parts flint glass, 80 parts red lead, 32 parts borax, 24 parts flint, 28 parts white enamel, 14 parts oxide of copper, ½ part oxide of cobalt.

Red Brown.—2 parts calcined sulphate of iron, 3 parts red lead, 2 parts borax, 1 part flint.

Sky Blue.—15 parts flint glass, 5 parts white lead, 1 part pearl ash, 1 part common salt, 2 parts oxide cobalt, 2 parts white enamel.

Chrome Green.—18 parts flint glass, 18 parts white lead, 4 parts oxide cobalt, 2 parts oxide of tin, 9 parts oxide of chrome, 20 parts borax.

All the foregoing enamels are first mixed, then melted in crucibles, poured out when liquid, then powdered or ground for use.

(*c*) To enamel cast iron and hollow ware: (1) Calcined flints 6 parts; Cornish stone or composition 2 parts, litharge 9 parts, borax 6 parts, argillaceous earth 1 part, nitre 1 part, calx of tin 6 parts, purified potash 1 part. (2) Calcined flints 8 parts, red lead 8 parts, borax 6 parts, calx of tin 5 parts, nitre 1 part. (3) Potter's composition 12 parts, borax 8 parts, white lead 10 parts, nitre 2 parts, white marble calcined 1 part, purified potash 2 parts calx of tin 5 parts. (4) Calcined flints 4 parts, Potter's composition 1 part, nitre 2 parts, borax 8 parts, white marble calcined 1 part, argillaceous earth ½ part, calx of tin 2 parts.

Whichever of the above compositions is taken must be finely powdered, mixed and fused. The vitreous mass when cold is ground, sifted and levigated with water; it is then made into a pap with water, or gum water. This pap is smeared or brushed over the interior of the vessel, dried, and then fused with a proper heat in a muffle. Clean the vessels perfectly before applying.

(*d*) Clean and brighten the iron before applying enamel. The enamel consists of two coats—the body and the glaze. The body is made by fusing 100 lb. ground flints, 75 of borax, and grinding 40 lb. of this frit with 5 lb. of potter's clay in water, till it is brought to the consistence of a pap. A coat of this being applied and dried, but not hard, the glaze powder is sifted over it. This consists of 100 lb. Cornish stone in fine powder, 117 of borax, 35 of soda ash, 35 of nitre, 35 of sifted slaked lime, 13 of white sand, and 50 of pounded white glass. These are all fused together; the frit obtained is pulverised. Of this powder, 45 lb. are mixed with 1 lb. of soda ash, in hot water, and the mixture dried in a stove is the glaze powder. After sifting this over the body coat, the cast iron article is put into a stove, kept at a temperature of about 212°, to dry it hard, after which it is set in a muffle-kiln, to fuse it into a glaze. The insides of pipes are enamelled (after being cleaned) by pouring the above body composition through them, while the pipe is being turned around to ensure an equal coating; after the body has become set, the glaze pap is poured in in like manner. The pipe is finally dried in the kiln.

(*e*) *For Culinary Vessels.*—For enamelling cast and wrought iron vessels, the following are the method and materials most generally employed: 100 lb. calcined and ground flints, and 50 lb. borax, calcined and finely ground, are intimately mixed, fused, and gradually cooled. Of this, 40 lb. are mixed with 5 lb. potter's clay, and ground in water to a pasty mass. The vessel, first thoroughly cleansed by means of very dilute sulphuric acid and scouring with sand, is lined with a coating of this about ⅛ in. thick, and left for it to harden in a warm room. A new coating is next added, prepared from 125 lb. white glass free from lead, 25 lb. borax, 20 lb. soda in crystals, which have been pulverisedand fused together ground, cooled in water, and dried. To 45 lb. of this, 1 lb. soda is added; the whole is mixed in hot water, dried, and finely powdered. A portion of this is sifted over the other coating while it is still moist, and the vessel is then dried in an oven at the temperature of boiling water 212° F. (100° C.). The vessel is heated in a stove or muffle till the glaze appears. It is then taken out, and more glaze powder is dusted on the glazed surface already in fusion. This enamel resists perfectly the action of dilute mineral and vegetable acids, as well as alkalis, and does not crack or scale off from the metal.

(*f*) *Enamelling Inside of Iron Saucepans.*— The article is first cleansed from all oxides by placing it in an acid solution, then dried, after scouring with sand to a grey colour, which shows it to be perfectly clean; apply a solution of gum-arabic to the surface, and sift over it a vitreous substance reduced to fine powder, composed of flint glass, soda carbonate, and boracic acid; then heat it to redness by degrees, till the glass is melted upon the surface. It is then allowed to cool gradually (excluded from the air as much as possible) to anneal it. The glaze is made of 130 parts glass, 20½ soda carbonate and 12 boracic acid, melted in a crucible, cooled, and then reduced to an impalpable powder. (R. W. Hale.)

(*g*) *For Cast-Iron Pipes.*—There are various recipes for the enamel, depending on the purpose for which it is applied. One for water pipes is as follows: 28 parts by weight of silica, 11 calcined soda carbonate, and 6 lime carbonate. Another is: 34 silica, 11 soda carbonate, 12 chalk, and 11 dried pipe-clay, to which boracic acid or lead oxide can be added when a more vitreous enamel is required. The core forming the inner surface of the pipe—and, if desirable, the mould too—is coated with graphite (blacklead), smoothed, and the enamel, as a powder, paste, or pigment, is applied to the thickness required. The molten iron causes the enamel to soften and firmly adhere to the iron. If it is not necessary that the enamel should be smooth, the blacklead is omitted.

(*h*) *Glass Enamel for Iron.*—The articles, kitchen utensils, signs, etc., coated with this enamel, are not affected by atmospheric influences, nor destroyed by an ordinary fire, and do not rust.

Intimately mix 4 parts of powdered glass, 2 of spar, 1 of saltpetre and ¼ of a part of zinc oxide. Fuse them in a crucible and pour into moulds to cool. For use the necessary quantity is triturated with water. Heat the iron utensil to a red heat in a muffle furnace and apply the enamel, which will present a brilliant glassy appearance. To colour the enamel blue, add oxide of cobalt ; for red, ammonium ; for black, manganic oxide ; for yellow, uranic oxide ; for brown, ferric oxide ; for green, a mixture of 2 parts of stannic oxide and 1 of manganic oxide ; for pure white, stannic oxide.

(*i*) *For Wall-plates.*—Thin sheet-iron is first cut and stamped to the desired shape, the edges of the plate being turned up slightly in the usual way so as to form a shallow tray, the edges serving to hold the enamel in position during the preliminary stages of the process. The plate is then made chemically clean by any of the ordinary processes of pickling and scouring. The ingredients of the enamel should be taken in the following proportions : White-lead, 12 oz. ; arsenic, 2½ oz. ; flint-glass, 8 oz. ; saltpetre, 3 oz. ; borax, 6¾ oz., and ground flint, 2 oz. These are powdered, mixed thoroughly, placed in the crucible, and fused ; but before they are cooled, they must be plunged into cold water, which has the effect of rendering the mass very brittle. The cakes of fused enamel are then pounded to about the fineness of coarse sand, washed, and dried. The powder is now ready for use. The plates of sheet-iron, having been well cleansed and thoroughly dried, are sprinkled over with sufficient enamel powder to make the coating of the desired thickness, and are then placed in a muffle, the turned-up edges retaining the swelling enamel in position. Lettering or designs can be produced on the surface by the ordinary means ; but if it is desired to put them on when the enamelled plate is cold, they are first received on paper, an impression being taken in soft black enamel from the engraved plate, and subsequently transferred, the article being again placed in the muffle to fuse the enamel of the design or letters. The iron back is more durable than copper, and cheaper. Variations in the colour of the enamel can be obtained by the addition of various salts and earths, such as cobalt, manganese peroxide, iron protoxide, etc., and similar diversity of colour can be introduced into the design or the letters.

(*j*) *White Enamel for Ornamental Articles.*—Calcine together and convert completely into oxide 2 parts of tin and 1 of lead. Mix 1 part of this oxide mixture with 2 parts of pulverised white crystal glass, and after adding a very small quantity of saltpetre as a decolorising agent, fuse in a small crucible, and pour the fused mass into cold water. Repeat the fusing twice or three times or until the mass is no longer blistered, but thoroughly homogeneous. It is then reduced to a fine powder, and may be applied either by itself, or, for small surfaces, by mixing it with oil of lavender and laying it on like oil paint with a brush. For the preparation of white enamel with a lower fusing point, the following composition may be used : 100 parts of the tin-lead oxide, 60 of pure quartz meal, and 25 of common salt. The iron contained in the sand combines with the chlorine of the common salt to a combination which evaporates on heating, and a fritted mass representing a lead-soda glass is obtained. To prepare enamel with this mass, it is finely pulverised and mixed with a zinc oxide, or with the mixture of tin oxide and lead oxide, by using 100 parts of oxide to 50 of the frit. The larger the quantity of tin oxide in the enamelling mass the thinner the coating may be. Enamelling masses containing no tin oxide may also be prepared, sodium antimonate being generally used in this case. A composition giving a very beautiful enamel consists of a mixture of 3 parts of crystal glass, 1 of sodium antimonate, and a very small quantity of saltpetre. In preparing all these kinds of enamel care must be taken in fusing to prevent the action of reducing bodies in the crucible by closing the latter with a well-fitting lid. If fire gases penetrate into the crucible, enamelling masses of inferior quality are obtained.

(*k*) *Coloured.*—The ordinary grey enamel (so called) is really not an enamel, but a transparent glaze, the apparent grey colour of which is produced by the surface of iron beneath the glaze.

(*a*) *Grey Mixture.*

	lb.	oz.
Sand	10	0
Red-lead	33	0
Boracic acid . . .	20	0
Cullett (broken glass)	114	0
Soda bicarbonate . .	16	0
Nitre	1	2
Manganese . . .	0	8½

(*b*) *Grey Mixture.*

Flint	36	0
Boracic acid . . .	24	0
Soda bicarbonate . .	24	0
Nitre	18	0

(*c*) *White Mixture.*

Cullett	11	0
Boracic acid . . .	7	0
Soda bicarbonate . .	0	4
Lime phosphate . .	3	8
Antimony oxide . .	0	2

Copper and other Vessels.—(*a*) Flint glass 6 parts, borax 3 parts, red-lead 1 part, oxide of tin 1 part. Mix all together, fuse, grind into powder, make into a thin paste with water, apply with a brush to the surface of the vessels (after scaling by heat and cleaning them), repeat with a second or even a third coat, afterwards dry, and then fuse on by heat of an enamelled kiln.

(*b*) In Germany and France the following process has lately come into use, especially for enamelling copper culinary vessels: 12 oz. white fluor-spar, 12 oz. gypsum, 1 oz. borax, are finely powdered, intimately mixed, and fused in a crucible; the mass produced is poured out, allowed to cool, and rubbed up to a paste with water. The paste is then brushed over the inside of the vessel to be enamelled : after thorough drying, the vessel is gradually heated until the enamel fuses. The coating thus produced is firmly adherent to the copper, is white and opaque, does not easily chip off, and is proof against vegetable acids. It also gives a beautiful alabaster surface for ornamental purposes. ('Ding. Polyt. Jl.')

(*c*) *White Enamel for Copper Cooking Utensils.*—Powder and mix 12 parts of white fluor-spar, 12 of unburned gypsum, and 1 of borax, and fuse the mixture in a crucible. Pour the mass out, and, when cold, triturate it into a paste with water. Apply this with a brush to the inside of the vessel and place the latter in a moderately warm place so that the paste will dry uniformly. When dry, heat the vessel to such a degree in a muffle furnace that the paste which has been applied liquefies. When cold, the result will be a white opaque enamel.

Cast Iron Baths.—In a paper read by T. Deadman before the Croydon Ironmongers Assistants, the author gave some little known details relating to Bath Enamelling. He explained that "porcelain" enamelling meant coating with china, "vitreous" enamelling coating with glass, and "metallic" enamelling coating with paint. To porcelain-enamel a bath one must first have a good casting, of a fairly even thickness, and free from "flaws." Such castings require to be filed up to remove all roughness, and also to expose all "blow-holes," etc., which are often covered with a mere skin of metal, which naturally collapses when touched with the emery-wheel or file. When this has been done the bath is placed in a sort of cupboard to be sand-blasted, to remove all carbonaceous deposits. This is the dirtiest part of the process, and the operator has to wear a protecting helmet, something like that used by divers. The casting is next handed to the enameller, who overhauls it for faults or blemishes, which must be rectified before he can proceed. If the examination proves satisfactory, the bath is placed over a tray and "undercoated" with a special composition poured on with a hand bowl and rocked so as to ensure an even thickness. The bath has then to be dried, and rubbed down with fine glass paper, and any bare places "touched up." It is next placed in the furnace to be "roasted." The process of undercoating prevents rust, and also forms a body for the enamel to attach itself to. After this the bath is placed in the furnace, brought to a white heat, and transferred on to a tilting and revolving table, when an overhead sieve arrangement is put into action, which sends down showers of dust enamel. The enameller in charge stands by with a long-handled sieve, and when he sees a bare or thin place he dusts on enamel. When he is satisfied with the appearance, or the bath becomes too cold, it is taken off the table, replaced in the furnace, brought to white heat again, and then taken out and examined for thickness of enamel and also for blemishes. If necessary, it is again placed under the enamelling-machine, and goes through the process again and again, until the enameller is satisfied. Baths are put through the process four or five times before they are considered perfect, and even then some turn out to be "wasters" or "seconds."

When the enamelling is finished the bath is placed under a large hood, which lets down to within a foot of the ground to allow of ventilation, while keeping the dust and dirt away during the process of cooling, which has to be done gradually and out of draughts. If a current of cold air were to reach it the metal would contract too quickly in some places, and the result would either be a broken bath or spoilt enamel. At that stage the surface of the bath is rough to the touch, the roughness being caused by small particles of enamel resting on the surface after the bath was too cool to cause the same to "flow." To remove this the surface has to be rubbed over with the finest glass-paper. Some enamellers, especially in Scotland, prefer to use long-handled sieves, about 8 in. diameter, for dusting on the enamel instead of the overhead arrangement described, but the latter allows the workers more freedom, and also enables them to get further away from the intense heat.

Vitreous enamelling is similar to porcelain enamelling, save that glass is used instead of china, and is obtainable in a greater variety of colours. The majority of coloured enamelled baths now on the market are "vitreous."

Where "metallic" enamelling is required, the casting is treated as before mentioned as regards filing-up and sand-blasting, and is then painted, placed in an oven, and baked; brought out again, allowed to cool, and then rubbed down with fine-glass paper as if for coach-painting. Another coat of paint is applied and the process repeated over and over again, according to the quality and style of finish required, some of the best finish requiring eight, ten, or even twelve coats of enamel paint to make them perfect specimens of the enameller's art. With metallic enamel practically any colour might be had and almost any combination, and some "marbled" baths are so well done that it needs an expert to tell whether they are marbled or only enamelled.

The Composition and Process of Commercial Enamelling.—The composition of the enamel is as follows: Silica, 100 lb.; soda-ash, 35 lb.; borax, 75 lb.; plaster of Paris or gypsum, 10 to 20 lb.; and arsenious acid in the proportion of $1\frac{1}{8}$ per cent. of all the other ingredients. When these are compounded the resultant mixture is an enamel vitreous enough to carry a glaze of itself, with an affinity for wrought or sheet iron which causes it to adhere with extreme tenacity when burned upon it, and which will not exfoliate or absorb moisture in quantity sufficient to destroy its polish. The ingredients of the enamel, having been comminuted, are carefully mixed together, and brought to a state of complete vitrification in a reverberatory furnace, with observance of the rules applicable to glass-making generally. Then the enamel is run off as usual into water to granulate, when it is ready for grinding. In making an enamel for wrought or sheet-iron ware, 100 lb. of the enamel is ground in an ordinary porcelain mill, adding about 5 lb. clay, preferably white, and having a pronounced soapy feeling, which clay helps to give body to the enamel and to prevent its crazing when it is finally fixed on the iron in the heat of a muffle. This grinding requires about one working day, and should always be continued until the enamel is thoroughly ground, and the clay is thoroughly mixed with it. It is advisible to introduce along with the enamel and clay in the grinding process, calcined magnesia carbonate in the proportion of 8 oz. to 100 lb. of the enamel. This salt of magnesia serves to make the enamel coat as finally applied less transparent, contributes to the flecking or spotting of it with white, and thus in a measure prevents the iron base from imparting to the enamel throughout its own dull and unattractive shade. Prepared as above, the mixture is run off through a strainer into tubs, where it is allowed to remain about 1 day, during which time a sort of ripening is effected, when it is finally prepared as follows: The mixture being brought to about the consistence of cream by the addition when necessary, of water, magnesia sulphate is added until the mixture is coagulated and pasty, yet still capable of being shaken out into a thin and uniform coat. 2 oz. magnesia sulphate is usually sufficient for 100 lb. of the mixture. The mixture having been finally prepared, the article is dipped into it, having been first prepared by the well-known processes of annealing, pickling, scouring, and washing. For washing clear water is used, the iron remaining therein until it is dipped. Care should be taken that the enamel is not laid on too heavily, and that it is evenly distributed. Having received a thin uniform coat by dipping, the article is dried, for if the enamel coat is burned while still damp it will crack or craze. This drying is accomplished, for convenience and dispatch, in an oven constructed for the purpose, the range of heat in which varies from about 100° to 200° F. (38° to 93° C.) but it may be effected at summer heat in an ordinary close room. The higher the temperature, the smaller and less distinct the spots; the lower the temperature, the more pronounced the mottlings. The time required depends upon the thickness of the enamel coat, the quantity of moisture present, and the degree of heat employed. When thoroughly dried the coat is of a whitish colour and usually either brown or reddish-brown spotted; and when burned in a muffle is of greyish colour, dark spotted. The burning process is effected in an ordinary muffle at a red, cherry-red, or slightly greater heat, the ordinary time required being about 4 minutes. (Quinby and Whiting).

To Remedy Faults in Enamelling.—When the enamel becomes separated from the metal or when the iron bends away from the enamelled side, i.e. when the contraction of the enamel on cooling is less than that of the iron, one of the following alterations must be made in the composition of the enamel.

(*a*) Increase the amount of silica.

(*b*) Replace part of the boric acid by silica.

(*c*) If lead is present, replace part of the lead oxide by alkalis or alkaline earths.

(*d*) Replace part of the alkaline earths by alkalis.

(*e*) Increase the alkalis and diminish the boric acid.

(*f*) Instead of tin oxide use bone ash.

If the enamel breaks, and the iron bends towards the enamelled side, and the contraction of the enamel is therefore greater than that of the iron, the constituents must be altered in the opposite sense. The following relations by weight give, according to Petrik, good and reliable enamels :—

	PbO	Na_2O	SiO_2	B_2O_3	SnO_2	CaO
I.	30·8	18·5	47·1	3·6	..	..
II.	15·4	18·5	47·1	3·6	15·4	..
III.	32·4	6·0	58·1	3·4	..	..
IV.	..	18·5	63·3	7·8	..	10·4
V.	..	18·5	36·7	14·0	30·8	..

	Na_2O	SiO_2	B_2O_3	SnO_2	Bone Ash
VI.	18·5	52·1	14·0	15·4	..
VII.	18·5	36·7	14·0	..	30·8
VIII.	18·5	36·7	14·0	15·4	15·4
IX.	18·5	52·5	14·0	7·7	7·7

The relation between tin oxide and bone ash is of great importance. ('Monit. de la Céramique et de la Verrerie.')

Clock and Watch Makers' Enamelling.—Dial-plate enamelling includes the manufacture of watch and fine clock dial-plates, with fluted plates for enamel painting, and is divided into two branches—hard enamelling, and soft or glass enamelling. In the first branch, the Venetian enamels only are used; in the last, the English or glass enamels. The practice of hard enamelling requires more skill, time, and labour than the others, and is consequently esteemed the most. In preparing the metals to be enamelled on, whether they be of gold, silver, or copper, the process is similar, and one description will suffice for the whole; and first of the making of watch-dials.

The copper plates having been prepared to the necessary shape and size, and an edge raised round the holes, and on the outside circumference, to prevent the enamel from spreading when it is in its soft state, the coppers are then thrown into a pickle-pan in order to free them from any impurities which may be on the surface. This pickle is composed of oil of vitriol, sufficiently neutralised for the purpose with water; or diluted nitric acid may be used. The coppers being thus prepared, the next step is that of enamelling. When the operations of hard enamelling and glass enamelling are dissimilar, the difference will be described; but to a certain extent they are the same. The enamel as it comes from the maker is generally in small cakes, 4 to 6 in. in diameter. In preparing it for use, a small hammer is used, having one end flat and the other of the shape commonly employed to rivet with. With this the enamel is broken into thin pieces or flakes, by striking the edge of the cake smartly as it rests upon the fore-finger of the left hand. The pieces are then put into an agate mortar, and with a pestle of the same material are finely pulverised, the splinters being prevented from flying about by keeping the enamel covered with pure water all the time the process of grinding is going on. The point at which it should be discontinued can only be ascertained by experience, as the different kinds of enamel and the different modes of its application require the ground enamel to be either more or less fine. In general, it may be stated that the "backing" should be much finer than the first coat, the second coat of an intermediate fineness, the hard enamels considerably finer than the glass, and the flux somewhat finer that these, as the first operates with much less effect on the flux than upon either of the former substances.

When grinding, great care must be taken to keep the enamel free from dirt, and the light flue which arises must be washed away, three or more times as may be necessary, in the course of the operation, till the water comes off quite clear. A small teapot is commonly used to pour the water from, and when the enamel is ground sufficiently, the produce is emptied into some other small cup for use, the surface being kept just covered with water. The manner in which the grinding is performed is by pasting the mortar upon the work-bench, on a coarse piece of flannel or linen, twice or thrice doubled and wetted to prevent its slipping. The handle of the pestle is then grasped firmly about the middle with one hand, and the palm of the other being placed on the top, the operator inclines the upper part of his body over the mortar, and crushes the enamel by pressing forcibly with his breast upon the hand which covers the pestle. The motion is repeated in quick succession, till all the larger pieces are reduced into coarse uneven grains, which grains are afterwards ground to the necessary fineness by holding the mortar firmly down with one hand, and with the other giving a circular direction to the pestle, using at the same time as much strength as can conveniently be exerted.

In enamelling watch-dials, many coppers are usually prepared to go on at once—that method possessing the threefold advantage of saving time, material, and labour. After the enamel has been ground, and the coppers cleaned by means of the pickle, and carefully brushed out with water, they are spread face downwards over a soft half-worn cloth, or smooth napkin, and a thin layer of hard enamel—called in its ground state the "backing"—is spread over the under sides with a point of a quill, properly cut for the purpose, or with a small spoon. The coppers are then slightly pressed on by another soft cloth or napkin, which, by imbibing some portions of the water, renders the enamel sufficiently dry to be smoothly and evenly spread with the rounded side of a steel spatula. The water is then again dried out by the napkin, and a yet further evenness produced by going over the enamel as before with the spatula; and these operations are continued till the back becomes completely smooth, and the enamel is of an equal thickness all over. It must be observed that the water should not be entirely absorbed, as in that case the enamel would fall off in powder before the subsequent operations were completed. When the enamel is properly spread, the loose particles are carefully cleaned away from the edge and hole, or holes, in the coppers; from the former by the spatula, from the latter by twisting around it the pointed end of a quill; and the process of laying the bottoms is thus finished. Some slight variations from the above method are in use among different artists, but the difference is scarcely important enough to require description. In some instances the enamel is laid on the spatula itself, and the coppers, instead of being held between the fingers, are placed on a round pin by means of the centre holes, till the backs are duly spread. In both modes due care must be taken that the coppers are not bent out of their proper forms.

The next operation is to lay the "first coats"; that is, to spread a layer of glass enamel over the upper sides of the coppers. In doing this, the surface is first brushed slightly over with a small camel's hair brush, or a hare's foot, to remove any dirt or extraneous particles of enamel, as the mixture of any hard enamel with the glass would infallibly spoil the work. The glass is then spread upon the copper in a layer, the thickness of which is commonly the same as the height of the projection round the edge of the copper, and round the edge of the hole. The water is afterwards slightly absorbed with a clean napkin, smoothly folded, and the enamel spread by a thin flat spatula, till all the unevenness is removed, and the surface lies regularly from the edges to the centre. The edge then being gently tapped 2 or 3 times at different places with the spatula, the water rises towards the top, and is again dried off with the napkin, when the enamel is once more made smooth by the spatula, and the water being wholly taken up by the napkin, or as nearly so as can be effected without disturbing the enamel, the first coats are placed upon rings for firing.

The rings employed in enamelling are generally made of a mixture of pipe-makers' clay and Stourbridge clay, rolled up in the form of cylinders, and turned in a lathe by means of a cylindrical piece of wood forced through the centre of the mass when wet. Each ring is about ¼ in. in thickness, and the same in depth. The upper side is prepared for use by rendering it slightly concave, which is done by rubbing it carefully upon a half-globe of lead, sprinkled over with fine sand. The under side is nearly flat. Through the convexity thus given to the rings, the edge of the copper or dial-plate only is suffered to touch, by which means the enamel on the back is undisturbed, and the edges are prevented from sticking by rubbing over the surface of the rings with soft chalk or whiting.

The "first coats" having been placed carefully on, the rings are next put into a shallow tin vessel, called a tin cover, which is either made square or round, according to the fancy of the workman, and is commonly about ¾ in. in depth. All the moisture is then slowly evaporated from the enamel by placing the cover upon a stove, or in some other convenient situation near a fire, where the evaporation can be conveniently regulated; for, should the water be dried off too quickly, the work will be in danger of spoiling from "blebs or blisters." These are very small air-bubbles, which, by rising to the surface of the dial-plates, destroy their smoothness and beauty. They appear to be occasioned partly by want of due care in laying on the enamel, and partly by the confinement of the air that the water contained, which, in the process of firing, becomes rarefied, throwing off by its expansion a portion of the surrounding enamel, yet not entirely escaping without a vivid heat, and even then resolving into black or green specks, so coloured by the oxidation of the copper.

The firing is executed beneath a muffle placed in a small furnace ignited with coke and charcoal. The furnace being brought up to a sufficient degree of heat, the first coats are taken separately from tin covers, and placed upon thin planches of clay or iron, chalked over, and gradually introduced beneath the muffle, where, in a very short time, the enamel melts; or, to speak technically, it "runs," and on becoming properly consolidated, the first coat is completed. Great attention is required in this operation to prevent the enamel from being over-fired, as in that case the glass would lose some portion of its opacity, and other defects also be produced, to the detriment of the work. The planches are placed towards the further extremity of the muffle by means of a pair of spring tongs, and as soon as the fusion seems to take place, are turned carefully round, in order that every part should be equally fired. The planches are generally made circular, and slightly concave, for the convenience of moving the work without danger of shaking off the enamel before it becomes fixed by the heat.

As all solids, when reduced to a granulated state, occupy a greater space than before, it will be found that a very considerable depression takes place in the enamel of the first coat by the action of fusion. This deficiency in substance it is the office of the "second coat" to supply. When the work is cooled, therefore, the scale is wholly removed, on the projection round the edge of the copper and round the holes, by means of a smooth file or by a piece of greystone, and being then washed and dried, each plate is put upon a small round wax block of sufficient bulk to be held in the hand, and about 4 or 5 in. high. The feet of the dial are then either pressed firmly into the wax which covers the end of the block, or the plate is otherwise fixed by means of 3 small cones of wax placed triangular-wise on the block, care being taken not to spread the enamel by too hard a pressure. A second layer of ground enamel is then gently spread with a quill, and prepared for firing by the napkin and spatula as before, after which the "second coats" are replaced upon the rings, and, the moisture being evaporated in the tin cover, they are ready for a second fire. It should have been mentioned that one edge of the cover, both in this and the preceding operation, should be left a little open to give issue to the steam.

The second firing requires equally cautious management. The plates must not be over-fired, nor must the heat be suffered to melt the enamel too rapidly, but a kind of rotary motion —technically called "coddling"—must be given to the work, by holding the loaded planch lightly with the tongs and gently drawing the edge of it towards the mouth of the muffle and then returning it to its former place till the fusion is complete, a proper knowledge of which can be gained only by experience. The work is now in a fit state for polishing.

Polishing Enamels.—Polishing in the art of enamelling has a twofold significance. It not only means to render bright—according to the common acceptance of the term—but also to make even, without any reference to glossiness. The enamel has a natural brightness of surface acquired from the fire, and when this is removed it is only necessary again to expose it to due heat to cause it to assume its former lustre. Yet as this brightness exists independently of evenness, and as evenness is essential to the perfection of enamelling, it is requisite in most cases to produce that quality by the method next to be described.

The materials used in polishing what are technically known as "glass-plates" are greystones, ragstones (sometimes called burrs), bluestones, and fine silver sand and water. The plates are first taken separately, and the thin edges are ground off by one of the greystones till they become smooth and equal. Either the greystone or the ragstone is next employed, according to the nature of the work, to grind away all the irregularities which may be on the surface of the enamel, the ragstone being principally used for the more common kinds of dial. This is done in different ways: first either by holding the plate upon the fore and middle finger of one hand, and giving it a sort of circular motion by means of the thumb, while with the other hand the polishing stone is rubbed with a forward and backward motion over every part of the surface: secondly, holding the polishing stone on the work bench with one hand, and with the other rubbing upon it the face of the enamel; or, thirdly, by fixing the plate upon a cork, either by means of the feet, or with a piece of wet flannel and with the fingers giving it a kind of a rotary motion while the polisher is rubbed over it in a similar manner. The ground silver sand is used to give sharpness to the polishing stones, and wear away the enamel with greater celerity. The act of polishing is continued till all the gloss is ground off the surface. In this operation care must be exercised that the pressure is not too powerful, as the plates will crack in the fire, and can never, or very rarely, be properly mended.

When the enamel is sufficiently polished, which can easily be known by the criterion of all the gloss being removed, the plates must be clean washed, and all the specks of dirt, etc., picked out with a sharp graver. They are then well rubbed over with some fine ground glass enamel, either by means of a cloth, or perhaps a small piece of fir-wood cut smooth, in order to remove the stains that may be left by the polishing stones, and, clean water being suffered to run over them, they are wiped dry and placed on rings for firing, as described. The degrees of heat necessary for glossing plates are determined by the fine or coarse modes by which they were prepared, as the fusion is much facilitated by the enamel being free from scratches. When the surface is properly run—i.e. when it becomes perfectly smooth, even, and bright—the plate is completed, and when cold is fit for painting on. The above description refers more particularly to the best kind of work. There are two other modes of enamelling watch-dials, which it will be required briefly to explain. The plates made by the following methods are called technically "run-down plates," and "run-down second coats."

Run-down plates are those which are made by laying enamel upon the copper in sufficient quantities to form plates of the required thickness without putting on a second coat. Both labour and fire are thus saved, but the neatness, regularity, and squareness obtained by the first method are scarcely obtainable in this; and indeed flat plates can hardly be managed at all by this mode. Running-down plates require more "coddling" than the others, and a longer continuance of vivid heat is necessary to make the glass flow to a proper evenness of surface, the plates being wholly completed with one heat and without polishing. It is obvious that only common work can thus be manufactured. For work of the next superior description, the run-down coats are polished off with the ragstone and undergo a second firing. The run-down second coats are those which are reduced to a comparatively even surface by a second firing, and then painted on without being polished off.

In enamelling hard plates for watches, the coppers and the first coats are prepared in the manner already described, excepting, perhaps, that the layer of glass is rather thinner than in glass work only. The hard enamel, which used to be much valued on account of its rich cream colour, is broken down and ground in the same way as the glass, if only a small quantity is wanted; but if otherwise, it is first broken from the cake with the hammer, and then pounded in a steel mortar till reduced to coarse grains. These grains are then exposed to the action of a magnet, in order that all the particles of steel that have been broken off the mortar in the act of pounding may be taken away, as they would infallibly spoil the work by rising in black specks to the surface of the enamel when exposed to the fire. As an additional precaution, it is also necessary to put the granulated enamel into a small basin, and pour upon it a strong solution of oil of vitriol, or aquafortis, and allow it to stand for some time, so that any steel particles which may be in the enamel may be completely dissolved. The enamel must then be very carefully washed till the water comes off pure and tasteless, for should any acid remain, the work would certainly blister.

The enamel is then ground to the necessary fineness in an agate mortar, as previously described, and afterwards spread over the first coats with a quill in small quantities, and as evenly as it can be laid, so that it may require the use of the spatula as little as possible. The water is then partly absorbed by a very fine, clean napkin, and the enamel is smoothly spread and closely compressed with the spatula, after which more water is absorbed, and the spreading is continued till the surface lies true and even. The plate is then put upon a ring and properly fired, and is afterwards polished by placing it upon a cork and grinding the surface, first by a fine file, or a smooth piece of steel with silver sand, ground to an almost impalpable powder; secondly by a fine bluestone and sand; and thirdly, by the bluestone alone. With the latter, a sort of half-polish should be given to the enamel, and the higher that polish approaches to complete glossiness the better, as the plate will then be finished in the fire with a less degree of heat than would otherwise be required. In this process much caution is required to prevent scratches which cannot be "run up" by the fire without giving the enamel a greater degree of heat than it will bear. It should be mentioned that before polishing the face of the dial, the top edges should first be taken off with a fine greystone.

When the polishing is completed, the plate is carefully cleaned with ground enamel, and should there be any specks they must be picked out with a small sharp diamond, and the hollows very dexterously filled up with enamel from a quill point, so that they may neither rise above nor sink below the general surface when the plate is again fired. Should they actually do so, they must be made smooth with a bluestone, and the plate must undergo a fourth firing to render the surface of uniform texture and glossiness. Hard enamel dials are always considerably more expensive than glass enamel ones, through the greater labour, attention, etc., that is requisite in making them. In the polishing off of both hard and glass enamel dial-plates, much care is required to prevent a separation of the enamel from the edge of the copper; for if too great a pressure is exercised, or if the stones which are employed to grind down the copper are too rough in the grain, the adhesion will be destroyed, and various black indents will arise round the edge of the enamel when the plate is again exposed to the fire. In glass enamel dials these defects may sometimes be amended, but in hard enamel dials scarcely ever.

Remedying Defects. — These directions for enamelling watch-dials may be concluded with some general observations upon the accidents that are most likely to occur in both kinds of enamelling, and in pointing out the best methods to remedy them when they do happen. When good Venetian enamel cannot be obtained, and mixtures of various kinds are resorted to, it frequently happens that the glass enamel plates crack when they are brought to the second fire. This is due to the unequal expansion of the two enamels, and when the cracking takes place at the top, or upper part of the plate, it requires very delicate treatment to preserve the dial from being completely spoiled.

To do this successfully, as soon as the crack is observed the plate must be withdrawn from the fire, and if the crack extends only from the centre hole to the edge, it will in most cases bear mending; but if it has cracked in two or three places, it will be useless to make the attempt, as it will rarely succeed. If the dial-plate were to continue in the fire a sufficient time after it was cracked, the enamel would close, and the plate become sound again. But as the copper on its surface is in a state of oxidation, the copper oxide uniting with the enamel would rise to the upper surface of the plate, producing by its union a joint, and sometimes a dark green line, which would evidently render the plate useless. The operator must then observe the time when the crack has opened to its greatest width, and before it unites or closes at the bottom, the plate must be withdrawn from the fire and allowed to cool. The opening must then be filled with fine enamel, laid sufficiently high to allow for its running down in the fire; but to adjust the quantity so as to prevent the appearance of a seam across the plate, will require much judgment; and indeed, however well the operation may succeed, it will still remain visible, because the new cement cannot be submitted to the process of "using off," as the plate would by such means be rendered very porous in some parts, and thereby attract dirt when the fingers touched the surface.

Another very common accident in making glass enamel plates is to "overfire" them, as it is technically called. Whenever this happens, the arsenic, which gives whiteness and opacity to the material, is converted into a flux by the extreme heat, and that part of the plate which has been so treated becomes semi-transparent and of a light blue colour. The only method that can be used in that case, is to return the plate into the fire, and give it a longer continuance of heat, but as slight as possible, just keeping it red-hot; and to do this conveniently, the plate should be placed near the front of the muffle, as the greatest heat is always at the back. This treatment will restore the plate to a tolerable degree of whiteness by reviving the powers of the arsenic, but it must never be expected to look as white as if it had been properly fired at first. Should any crack appear on a hard plate, it would be in vain to try to mend it, for as the shape of a hard enamel dial can be brought to great perfection when all parts of the process succeed, it is almost needless to say that the plate would suffer so very much in this point as to render it good for nothing; therefore, an accident of this kind in hard enamelling is always regarded as the close of an abortive attempt.

Transparent Enamelling.—The operations of transparent enamelling are nearly similar to what has been already described in enamelling dials. As the work is generally of a more minute kind, greater delicacy of handling is perhaps required, and as the enamels are of various colours and descriptions, more cups, vessels, etc., and additional soft cloths or napkins, are needful to keep and apply them. Watch-cases are usually enamelled upon gold, as well as most of the superior articles of jewelry, and the surface of the gold is frequently engraved in different figures and compartments before the enamel is laid on, by which means the work affords a beautiful variegated appearance. In enamelling the back and edges of watch-cases, etc., quince water is frequently used as the medium by which the enamels are laid on; this possessing a more adhesive and retentive quality than common water, helps to prevent the enamels from flowing from their proper situations, for when the convexity is considerable, the enamel will of course have a tendency to float towards the lowest part. When enamels of different colours are intended to be employed on the same article, which is frequently the case in ornamental work, small edges or prominent lines are left in the substance of the metal, for the purpose of keeping the enamels separate, and these are polished with the enamel, and reduced with it to a similar equality of surface. Transparent enamels are not unfrequently polished to complete glossiness without exposing them to an additional fire. In these cases the work is finished with rotten-stone.

It is sometimes desirable to remove the enamel from a watch-case or a piece of jewelry without injuring the metallic part. For this purpose, it has been recommended to lay a mixture of common salt, nitre, and powdered alum upon the enamel required to be removed, and afterwards to place it in the furnace; and when the fusion has commenced, to throw the watch-case or piece of jewelry suddenly into water, which causes the enamel to fly off in flakes.

In ornamental transparent work a very pretty effect is produced by applying small and very thin pieces of silver and gold, cut or stamped in different figures—acorns, oak leaves, vine leaves, bunches of grapes, etc.—upon the surface of the first coating of enamel, where they are fixed by the fire, and are afterwards covered over by the second layer, through which they appear with considerable beauty. When any quantity of fancy work or similar design is wanted, this mode of enamelling is considerably cheaper to execute than to have the surface of the metal itself engraved in the required forms.

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ENGRAVING.

(*See also* ETCHING, PHOTO-PROCESS ENGRAVING, STEREOTYPING, ETC.)

Wood Engraving.—Although the art of wood engraving for printing blocks is practically extinct—owing to the cheaper and more expeditious photo processes—yet there still exists considerable opening for its application, and its utility for the production of printing blocks for certain purposes is by no means ended yet.

Engravers' Lamp.—A clear and steady light, directed immediately upon the block to be cut, is a most important point, and in working by lamplight it is necessary to protect the eyes from its heat and glare. The lamp shown in Fig. 80 can be raised or lowered at pleasure by sliding the bracket up or down the standard, it being fixed in the desired position by means of the small set screw. A large globe of transparent glass, filled with clean water, placed between the lamp and the block, causes the light to fall directly upon the block. The dotted line shows the direction of the light; by lowering the lamp, this light would take a more horizontal direction, thus enabling the engraver to work farther from the lamp. A shade over the eyes is occasionally used as a protection from the light of the lamp.

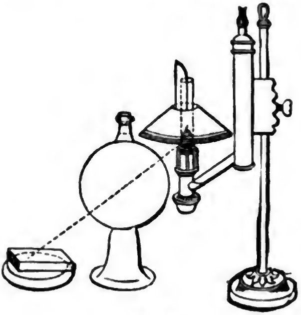


FIG. 80.

Tools.—These consist of gravers, tint-tools, gouges or scoopers, flat tools or chisels, and a sharp-edged scraper, something like a copper-plate engravers' burnisher which is used for lowering the block. Of each of these tools several sizes are required.

Gravers.—The outline tool Fig. 81 is chiefly used for separating one figure from another, and for outlines. A is the back of the tool; B, the face; C, the point; D is technically termed the belly. All the handles when received from the turner's are circular; but as soon as the tool has been inserted, a segment is cut away from the lower part so that the tool may clear the block. The blade should be very fine at the point, so that the line it cuts may not be visible when the block is printed, its chief duty being to form a termination to a number of lines running in another direction. Although the point should be fine, the blade must not be too thin, for it would then only make a small opening, which would probably close up when the block was put in the press. When the tool becomes too thin at the point, the lower part must be rubbed on a hone to enable it to cut out the wood instead of sinking into it.

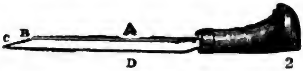


FIG. 81.

Nine gravers of different sizes, starting from the outline tool, are sufficient for ordinary work. The blades as made are very similar to those used in copper-plate engraving; the necessary shape for wood engraving is obtained by rubbing the points on a Turkey stone. The faces, and part of the backs, of nine gravers of different sizes, are shown on Fig. 82; the dotted line, A C, shows the extent to which the tool is sometimes ground down to broaden the point. This grinding rounds the point of the tool, instead of leaving it straight, as shown at A B. Except for the parallel lines, called *tints*, these gravers are used for nearly all kinds of work. The width of the line cut out is regulated by the thickness of the graver near the point, and the pressure of the engraver's hand.

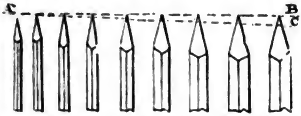


FIG. 82

Tint-tools.—The parallel lines forming an even and uniform tint, as in the representation of a clear sky, are obtained by what is called the tint-tool, which is thinner at the back but deeper at the side, than the graver, and the angle of the face at the point is much more acute, as shown on Fig. 83: A is a side view of the blade; B shows the faces of nine tint-tools of varying fineness. The handle is of the same form as that used for the graver. The graver should not be used in place of the tint-tool, as from the greater width of its point a very slight inclination of the hand will cause a perceptible irregularity in the distance of the lines, besides tending to undercut the line left which must be carefully avoided. Fig. 84 shows the points and faces of the two tools, from a comparison of which this statement will be readily understood. As the width of the tint-tool at B is little more than at A, it causes only a very slight difference in the distance of the lines cut, if inclined to the right or the left, as compared with the use of the graver. Tint-tools that are strong in the back are to be preferred as less likely to bend, and giving greater freedom of execution than weak ones. A tint-tool that is thicker at the back than at the lower part, leaves the black raised lines solid at their base, as in Fig. 85, the block being less liable to damage than in the case of Fig. 86, in which the lines are no thicker at their base than at the surface. The face of both gravers and tint-tools should be kept rather long than short; though if the point be ground too fine it will be very liable to break. When, as in Fig. 87, the face is long—or, strictly speaking, when the angle formed by the plane of the face and the lower line of the blade is comparatively acute—a line is cut with much greater clearness than when the face is comparatively obtuse, and the small shaving cut out turns gently over towards the hand. When, however, the face of the tool approaches to the shape seen in

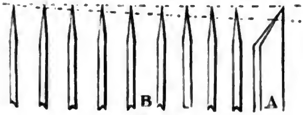


FIG. 83

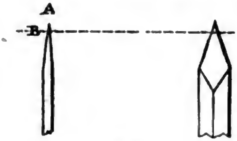


FIG. 84.

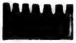


FIG. 85.

FIG. 86.

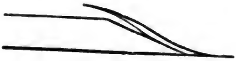


FIG. 87.

Fig. 88, the reverse happens; the small shaving is rather ploughed out than cleanly cut out; and the force necessary to push the tool forward frequently causes small pieces to fly out at each side of the hollowed line, more especially if the wood is dry. The shaving, also, instead of turning aside over the face of the tool, turns over before the point, as in Fig. 88, and hinders the engraver from seeing that part of the pencilled line which is directly under it. A short-faced tool of itself prevents the engraver from distinctly seeing the point. When the face of a tool has become obtuse it ought to be ground to a proper form; for instance, from the shape of the figure A to that of B, Fig. 89.

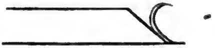


FIG. 88.

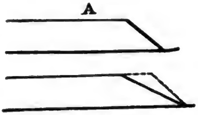


FIG. 89.

Preparing Gravers and Tint-tools.—Gravers and tint-tools, when first received from the makers are generally too hard—a defect that is soon discovered by the point breaking off short as soon as it enters the wood. To remedy this, the blade of the tool must be tempered to a straw colour, and either dipped in sweet oil, or allowed to cool gradually. If removed from the oil while it is still of a straw colour it will have been softened no more than sufficient; but should it have acquired a purple tinge, it will have been softened too much, and instead of breaking at the point, as before, it will bend. A small grindstone is of great service in grinding down the faces of tools that have become obtuse. A Turkey stone is a very good substitute, as, besides reducing the face, the tool receives a point at the same time; but this requires more time. Some engravers use only a Turkey stone for sharpening their tools; a hone in addition is of great service. A graver that has received a final polish on a hone cuts a clearer line than one which has only been sharpened on a Turkey stone; it also cuts more pleasantly, gliding smoothly through the wood, if it be of good quality, without stirring a particle on either side of the line. The gravers and tint-tools used for engraving on a plane surface are straight at the point, as are here represented, Figs. 90 and 91; but for engraving on a block rendered concave in certain parts by lowering, it is necessary that the point should incline slightly upwards as in Fig. 90. The dotted line shows the direction of the point used for plane surface engraving. There is no difficulty in getting a tool to descend on one side of a part hollowed out or lowered; but unless the point is slightly inclined upwards, as is here shown, it is extremely difficult to make it ascend on the side opposite without getting too much hold, and thus producing a wider white line than intended.

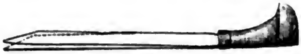


FIG. 90.

FIG. 91.

Gouges and Chisels, A to E, Fig. 92.—Gouges of different sizes are used for scooping out the wood towards the centre of the block; whilst flat tools, or chisels, are chiefly employed in cutting away the wood toward the edges, about ⅛ in. below the subject. The gouge is similar to an ordinary carpenter's gouge, except that it is solid, being a round bar, with the end ground off at an angle. The other articles required are : a sand-bag, on which to rest the block whilst engraving it ; an agate burnisher and a dabber, which are used for taking proof-impressions of the wood-cut ; an oil-stone, and an eye-glass with shade.

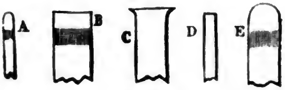


FIG. 92

Holding the Graver.—Engravers on copper and steel, who have much harder substances than wood to cut, hold the graver with the forefinger extended on the blade beyond the thumb, Fig. 93, so that by its pressure the point may be pressed into the plate. As boxwood, however, is much softer than these metals, and as it is seldom of perfectly equal hardness throughout, it is necessary to hold the graver in a different manner, and employ the thumb at once as a stay or rest for the blade, and as a check upon the force exerted by the palm of the hand, the motion being chiefly guided by the forefinger, as is shown in Fig. 94. The thumb, with the end resting against the side of the block, in the manner just represented, allows the blade to move backwards and forwards with a slight degree of pressure against it, and in case of a slip, it is ever ready to check the graver's progress. This mode of resting the thumb against the edge of the block is, however, only applicable when the cuts are so small as to allow the graver, when thus guided and controlled, to reach every part of the subject. When the cut is too large to admit of this, the thumb rests upon the surface of the block, as in Fig. 95, still forming a stay to the blade of the graver, and checking at once any accidental slip.

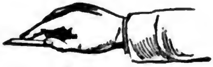


FIG. 93.

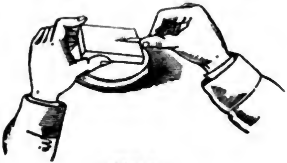


FIG. 94.

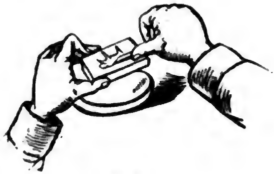


FIG. 95.

Wood.—For large coarse cuts, such as are often used for trade purposes, sycamore and pear tree may be employed, but they are too soft and irregular in the grain to bear fine work. Boxwood, either English, American, or from the Levant, is the favourite material ; it should be of a light straw yellow colour, free from black or white spots, or red streaks, as these indicate a soft wood, which crumbles away under the graver. The small wood is generally tolerably free from blemishes. When a large cut is wanted, if a block of the required size is not at hand, several smaller blocks are sometimes bolted together. The blocks are cut a trifle thicker than the height of type, about an inch ; they are then planed, brought to a very smooth surface, and gauged to the exact height of type. These blocks should be kept for some months until they are properly seasoned.

Drawing on the Block.—The polished boxwood will not take the pencil unless a slight wash is first laid on it. A thin wash of Chinese white mixed with water, some very fine Bath brick dust, or the white scrapings of glazed cardboard, mixed with water, and gently rubbed off when dry with the palm of the hand, gives a capital surface for the black-lead pencil. Make a tracing of the outline of the subject, place a sheet of transfer paper on the block lay the tracing over it, and go carefully over every line with a sharp point. It must be remembered that the woodcut will be reversed when printed. The outlines must be corrected, and completed by a hard sharp-pointed H H H H pencil; the tints may afterwards be filled in by a softer pencil, or thin washes of Indian ink, to show the effect of light and shade. Caution must be taken to use these washes sparingly, so as not to affect the wood. All parts of the block, not being cut, must be kept covered up, so as to preserve the drawing from injury, and the fine lines of the cut from being blunted or broken. Smooth blue glazed paper is very good for this purpose, as it reduces the glare from the lamp.

Proofs.—When the engraving is finished, a proof may be taken in the following manner before blocking out the cut, that is, before the superfluous wood is cleared away; rub down a little printers' ink on a slab till it is fine and smooth; take a little of this on a silk dabber, and carefully dab the block until sufficient ink is left upon the surface, without allowing any to sink below it. Lay a piece of India paper on the block with about two inches margin all round; on this place a thin smooth card; rub this over with the burnisher, taking care not to shift the card or paper.

Plugging.—If a slip or mistake occurs in a woodcut, it may be remedied by the insertion of a plug. A hole must be drilled in the block; if the error is a small one the hole need not be deep, but if a large piece has to be inserted it must be deeper in proportion. A plug is cut, of a round taper shape; the small end is inserted in the hole, and the plug is driven down, without, however, using too much force. The top of the plug must then be cut off, and carefully brought to a smooth surface, level with the rest of the block; if this is not done, the plug will be visible on the print. If the error to be remedied happens to be in a long line, a hole must be drilled at each end, and the wood between the two holes removed by small chisels, the hollow space being filled up in a similar way to that already described.

Copper.—Engraving on copper is performed by cutting lines representing the subject on a copper plate by means of a steel instrument, called a graver, or burin, ending in an unequal-sided pyramidal point. Besides the graver, the other instruments used in the process are a scraper, a burnisher, an oil-stone, and a cushion for supporting the plate. In cutting the lines on the copper, the graver is pushed forward in the direction required, being held at a small inclination to the plane of the copper. The use of the burnisher is to soften down the lines that are cut too deeply, and for burnishing out scratches in the copper; it is about 3 inches long. The scraper, like the burnisher is of steel, with three sharp edges to it; it is about 6 inches long, tapering towards the end. Its use is to scrape off the burr raised by the action of the graver. To show the appearance of the work during its progress, and to polish off the burr, engravers use a roll of woollen or felt, called a rubber, which is used with a little olive-oil. The cushion, which is a leather bag about 9 in. diameter filled with sand, for laying the plate upon, is now rarely used except by writing engravers. For architectural subjects, or for skies, where a series of parallel lines are wanted, a ruling machine is used, which is exceedingly accurate. This is made to act on an etching ground by a point or knife connected with the apparatus, and bit-in with aquafortis in the ordinary way.

COPPER PLATE.—The plate must be perfectly polished, very level, and free from any imperfection ; to this must be transferred an exact copy of the outlines of the drawing. To do this the plate is uniformly heated in an oven or otherwise, till it is sufficiently hot to melt white wax, a piece of which is then rubbed over it and allowed to spread, so as to form a thin coat over the whole surface, after which it is left in a horizontal position till the wax and plate are cold. A tracing having been taken of the original design with a black-lead pencil on a piece of thin tracing paper, it is spread over the face of the prepared plate with the lead lines downwards, and, being secured from slipping, a strong pressure is applied, by which operation the lead lines are nearly removed from the paper, being transferred to the white wax on the plate. The pencil marks on the wax are now traced with a fine steel point, so as just to touch the copper ; the wax is then melted off, and a perfect outline will be found on the copper, on which the engraver proceeds to execute his work.

Steel.—Engraving on steel is the same as copper-plate engraving, except in certain modifications in the use of the acids ; therefore, so far as the process is concerned, no particular description is necessary ; but the means employed for decarbonising and recarbonising first the steel plate, so as to reduce it to a proper state for being acted upon by the graving tool, must be explained. In order to decarbonate the surfaces of cast-steel plates, by which they are rendered much softer and fitter for receiving either transferred or engraved designs, pure iron filings, divested of all foreign matters, are used. The stratum of decarbonated steel should not be too thick for transferring fine and delicate engravings ; for instance, not more than three times the depth of the engraving ; but for other purposes the surface of the steel may be decarbonated to any required thickness. To decarbonate it to a proper thickness for a fine engraving, it is exposed for 4 hours to a white heat, enclosed in a cast-iron box with a well-closed lid. The sides of the box must be at least ¾ in. in thickness, and at least a thickness of ½ in. of pure iron filings should cover or surround the cast-steel surface to be decarbonated. The box is allowed to cool very slowly, by shutting off all access of air to the furnace, and covering it with a layer of 6 or 7 in. of fine cinders. Each side of the steel plate must be equally decarbonated, to prevent it from springing or warping in hardening. The safest way to heat the plates is to place them in a vertical position. The best steel is preferred to any other sort of steel for the purpose of making plates, and more especially when such plates are intended to be decarbonated. The steel is decarbonated to render it sufficiently soft for receiving any impression intended to be made thereon ; it is, therefore, necessary that, after any piece of steel has been so decarbonated, it should, previously to being printed from, be again carbonated, or reconverted into steel capable of being hardened.

In order to effect this recarbonisation or reconversion into steel, the following process is employed ; a suitable quantity of leather is converted into charcoal, by exposing it to a red heat in an iron retort until most of the evaporable matter is off the leather. The charcoal is reduced to a very fine powder ; then take a box made of cast iron of sufficient dimensions to receive the plate which is to be reconverted into steel, so that the intermediate space between the sides of the box and the plate may be about an inch. Fill the box with the powdered charcoal, and, having covered it with a well-fitted lid, let it be placed in a furnace similar to those used for melting brass, when the heat must be gradually increased until the box is somewhat above a red heat ; it must be allowed to remain in that state till all the evaporable matter is driven off from the charcoal; remove the lid from the box, and immerse the plate in the powdered charcoal, taking care to place it so that it may be surrounded on all sides by a stratum of the powder of nearly a uniform thickness. The lid being replaced, the box, with the plate, must remain in the degree of heat before described for 3 to 4 hours, according to the thickness of the plate so exposed; 3 hours are sufficient for a plate of ½ in. in thickness, and 5 hours when the steel is 1½ in. in thickness. After the plate has been exposed to the fire for a sufficient length of time, take it from the box and immediately plunge it into cold water.

The plates, when plunged into cold water, are least liable to be warped or bent when they are held in a vertical position, and made to enter the water in the direction of their length. If a piece of steel, heated to a proper degree for hardening, be plunged into water, and suffered to remain there until it becomes cold, it is very liable to crack or break, and in many cases it would be found too hard for the operations it was intended to perform. If the steel cracks, it is spoiled. Therefore to fit it for use, if it is not broken in hardening, it is the common practice to heat the steel again, in order to reduce or lower its temper. The degree of heat to which it is now exposed determines the future degree of hardness or temper, and this is indicated by a change of colour upon the surface of the steel. During this heating a succession of shades is produced, from a very pale straw colour to a very deep blue. On plunging the steel into cold water, and allowing it to remain there no longer than is sufficient to lower the temperature of the steel to the same degree as that to which a hard piece of steel must be raised to temper it in the common way, it not only produces the same degree of hardness in the steel, but, what is of much more importance, almost entirely does away with the risk of its cracking. The proper degree of temperature arrived at, after being plunged into cold water, can only be learned by actual observation, as the workman must be guided entirely by the kind of hissing noise which the heated steel produces in the water while cooling. From the moment of its first being plunged into the water the varying sound will be observed; and it is at a certain tone, before the noise ceases, that the effect to be produced is known. As a guide, take a piece of steel which has already been hardened by remaining in the water till cold, and by the common method of again heating it, let it be brought to the pale yellow or straw colour, which indicates the desired temper of the steel plate to be hardened. By the above process, as soon as the workman discovers this colour to be produced by dipping the steel into water and attending carefully to the hissing which it occasions, he will then be able, with fewer experiments, to judge of the precise time at which the steel should be taken out.

Immediately on withdrawing it from the water, the steel plate must be laid upon or held over a fire, and heated uniformly until its temperature is raised to that degree at which a smoke is perceived to arise from the surface of the steel plate after having been rubbed with tallow; the steel plate must then be again plunged into water, and kept there until the sound becomes somewhat weaker than before. It is taken out, and heated a second time to the same degree as before, and the third time plunged into water till the sound becomes again weaker than the last; exposed the third time to the fire as before; and for the last time returned into the water and cooled. After it is cooled, clean the surface of the steel plate by heating it over the fire. The temper must be finally reduced by bringing on a brown or such colour as may suit the purpose required.

The above is an old process, and not generally used. Engraving on steel is effected nowadays by graving and etching like copper; using for biting-in a mixture of 1 part pyroligneous acid, 1 nitric acid, 3 water; run off from the plate in less than a minute, rinse in running water, and dry quickly. Use stronger acid when a deep tint is required.

Engraving Steel Cylinders.—A cylinder of very soft or decarbonised steel is made to roll, under a great pressure, backward and forward on the hardened engraved plate till the entire impression from the engraving is seen on the cylinder in alto-relievo. The cylinder is then hardened, and made to roll again backward and forward on a copper or soft steel plate, whereby a perfect facsimile of the original is produced of equal sharpness.

Gold and Silver.—(*a*) The engraving is first exposed to the vapour of iodine, which deposits upon the black parts only. The iodised engraving is then applied, with slight pressure, to a plate of silver, or silvered copper, polished in the same manner as daguerreotype plates. The black parts of the engraving which have taken up the iodine part with it to the silver, which is converted into an iodide at those parts opposite to the black parts of the design. The plate is then put in communication with the negative pole of a small battery, and immersed in a saturated solution of sulphate of copper, connected with the positive pole by means of a rod of platinum. Copper will be deposited on the non-iodised parts, corresponding to the white parts of the engraving, of which a perfect representation will thus be obtained; the copper representing the white parts, and the iodised silver the black parts. The plate must be allowed to remain in the bath for only a very short time, for, if left too long, the whole plate would become covered with copper. The plate, after having received the deposit of copper, must be carefully washed, and afterwards immersed in a solution of hyposulphite of soda to dissolve the iodide of silver, which represents the black parts; it is then well washed in distilled water, and dried.

(*b*) Heat a silver plate previously coated with copper to a temperature sufficient to oxidise the surface on the copper which successively assumes different tints, the heating being stopped when a dark-brown colour is obtained. It is then allowed to cool, and the exposed silver is amalgamated—the plate being slightly heated, to facilitate the operation. As the mercury will not combine with the oxide of copper, a design is produced, of which the amalgamated parts represent the black, and the parts of the plate covered with oxide of copper represent the white parts. The amalgamation being complete, the plate is to be covered with three or four thicknesses of gold leaf, and the mercury is evaporated by heat, the gold only adhering to the black parts. The superfluous gold must then be cleared off with the scratch-brush; after which the oxide of copper is dissolved by a solution of nitrate of silver; and the silver and copper underneath are attacked with dilute nitric acid. Those parts of the design which are protected by the gold, not being attacked, correspond to the black parts of the plate; the other parts, corresponding to the white parts of the engraving, may be sunk to any required depth. When this operation is completed, the plate is finished, and may be printed from in the ordinary method of printing from woodcuts.

(*c*) To obtain from the same prints plates with sunk lines, similar to the ordinary engraved copper-plates, a plate of copper, covered with gold, is operated upon. On immersion in the sulphate of copper solution, the parts corresponding to the white parts of the engraving will become covered with copper. The iodine, or compound of iodine, formed, is then removed by the hyposulphite; the layer of deposited copper is oxidised, and the gold is amalgamated, which may be removed by means of nitric acid, the oxide of copper being dissolved at the same time. In this instance the original surface of the plate corresponds to the white parts of the print, and the sunk or engraved portions to the black parts, as in ordinary copper-plate engravings.

Relief or Printing Plates.—*Joyce Process.* Take a smooth metallic plate, covered with a thin coating of clay, plaster, or equivalent material applied in a plastic state. A mixture of ground potters' clay and plaster of Paris, nearly equal parts, moistened with water to the consistency of mortar; or ground soap-stone, chalk, or other material may be used.

The material is spread upon the metal plate and scraped down to any desired thickness, accordingly as lines are required in high or low relief. the thickness of the coating determining the relief elevation of lines in the finished plate.

It is usual to dry the plaster coating before any portion is cut away, but this is not essential.

The design may be pencilled, traced or transferred upon the surface of the plaster, or an artist sufficiently skilled may work without any copy. The coating is then cut away for the lines, entirely through to the metallic plate.

Points, needles, gravers, etc., may be used for cutting or scratching away the material. When the design has been completed, the lines are cleaned out with a soft brush, or blown out with a bellows.

The plate at this stage of the operation resembles a mould for a stereotype plate as used in the clay or plaster process of stereotyping, except that the lines and letters are cut entirely through the plaster.

The mould or matrix is now made ready, and a metal stereotype plate is cast upon it in any manner usual in the stereotyper's art. This plate is finished up in the ordinary manner, and if more relief is desired for the lines, the low portions of the plate may be cut or routed out.

Door plates and other ornamental relief line plates may be made in the same manner.

Relief line plates can thus be made in a very short time. It is especially adapted for the speedy reproduction of plates for maps, diagrams, plans, etc.

Hoke or Star Process.—The base plate of the engraved plate for stereotyping purposes is preferably a polished blued steel plate of suitable superficies. It withstands the heat incident to stereotyping, and its tint, when a light-coloured coating is used, presents a marked and agreeable contrast to the coating, and enables the engraver to readily judge the effect of his work. For electrotyping purposes, a base plate of glass is preferred. Glass is also an excellent material in combination with the special coating, and its transparency enables the engraver to examine his work by holding the plate to the light.

For the coating of the plate a finely powdered inorganic substance which will withstand the heat of molten stereotyping metal—is used. The more thoroughly and evenly the material is comminuted, and the more marked the contrast in colour between the coating and the base plate, the better is the engraving plate adapted for the purpose in view.

The leading features are that the particles of the coating next to the base plate adhere thereto more strongly than the particles above them adhere either to them or to each other, and that the coating is very friable and the particles very loosely as well as very evenly bonded together, so that they readily separate without caking and without breaking away between the lines when the plate is engraved; bonding the particles of the coating to each other and to the base plate with soluble glass or an equivalent soluble mineral alkaline bond; bonding the particles of the coating to each other and to the base plate by treating the particles with a solution of soluble glass, and then baking the coated base plate until the coating is dried; mixing together the ingredients to be bonded, then adding a water glass in solution, and then subjecting a base plate coated with the mixture to a heat beneath the boiling-point and not under 100° F. until the coating is solidified, after which the heat may be increased without injury to the coating; the special combination of substances given in the formula is used to form the coating upon the base plate.

In engraving a design in the matrix, it is highly desirable that the engraver shall be able to see distinctly the lines made through the coating, and thereby judge correctly the work being done. To this end the coating is made white or light-coloured, while the surface of the base plate appears dark, and the end is more effectually attained by employing a blued steel plate for the base plate.

The coating consists of 2 dr. barium sulphate (barytes), 2 dr. magnesia silicate (French chalk), 1¾ dr. soda silicate, 4 drops water. This mixture will cover sufficiently thick 6 sq. in. of plate.

The more perfectly it is mixed, the better the plate. A good way to make the mixture is first to mix the earth with water, and work and rub the ingredients in a mortar until the mixture becomes smooth, and then add the solution of soluble glass, and mix it with the other ingredients as thoroughly as practicable. The mixture should then be spread evenly over the base plate, shaking it slightly to settle the coating evenly. The coating should, after being placed on the plate, be dried by heat, preferably between 180° and 190° F., until it solidifies, after which the heat may be increased as high as 300° F. without injury to the coating. The object in keeping the heat beneath the boiling-point, while the coating remains in a semi-liquid state, is to prevent its boiling. The coating should be thoroughly dried. The coating at its top is usually incrusted, and after the plate has cooled, and before it is engraved, the crust should be scraped off, and the coating made of a uniform depth over the surface of the base plate.

When the coating is mixed very slowly, it may be baked at once; but otherwise it should be allowed to stand after mixing for at least 5 minutes before baking, and it is rather improved by being allowed to stand longer. The object is to allow the air contained in the mixture to escape as far as possible, and to prevent the coating from curling up and cracking while being dried.

The above method of mixing and baking is not the only one that can be used. The essential points are first to introduce the bond in the form of a solution into the body of the coating, and then to dry the coating upon the plate.

Instead of mixing the bond with the water and earths in the manner above described, the mixture may be made without the bond, and dried, with or without artificial heat, upon the base plate, and the coating may then be saturated with a solution of soda silicate containing 25–50 drops of soda silicate to 1 oz. water, and then baked as first above directed.

The formula above given may be widely departed from and good results still obtained, so long as the bond is of the proper nature and is used in the proper proportion. Either magnesia silicate or barium sulphate may be used alone in place of the mixture, though not so good. Barium sulphate is somewhat undesirable when used alone, because a coating made of it has a tendency to crack in drying.

All kinds of light-coloured earths may be used. Those which have the least attraction for water are the best. The clays are perhaps the least desirable of all, because of their tendency to crack when drying. It is desirable where they are used to mix them with an equal bulk of plaster of Paris or with some other substance which will prevent cracks, as the bond will not perform that function when used in the proper proportion.

The most desirable earths—naming them in their order of merit—are soapstone, tripoli, talc, quartz, and chalk.

Barium sulphate, though excellent when mixed with magnesia silicate, is not so good when used singly. Mixing a very light with a very heavy earth is a good course to follow. The specific gravity of a mixture of barium sulphate and magnesia silicate in the proportions named is the most desirable.

Where less than two drops of bond are used, the plate is very poor, because insufficiently bonded. Where more than eight drops are used, the coating is made too hard to be entirely satisfactory, and is more or less liable to break away from the base plate when being engraved.

A test as to the amount of water to be used is that the mixture when made should be thin enough to pour out of a containing vessel, but no thinner than necessary for that purpose. It should be of about the consistency of batter, so that a small portion will cling to the side of the vessel from which it is poured. Clay is an exception to the general rule as to the amount of water necessary. Where it is used, only one-half the quantity of water necessary for other substances should be used.

Hansen Process. — (*a*) Provide a smooth level plate of some suitable hard material and of a size somewhat exceeding that of the engraving which it is desired to produce. A piece of plate glass will answer admirably. The face of this plate is covered with a thin coating of tallow, lard, oil, or beeswax, spread evenly and enabling a sheet of tinfoil to adhere to the composition with such tenacity as to prevent it from being displaced when manipulated.

The tinfoil, having been attached to the composition on the plate, is ready for the draughtsman or artist, who, with a style, pencil, or other instrument, proceeds to draw the sketch of which an engraving is required, taking care to exert sufficient pressure to indent the tinfoil to the depth of the base plate, the intervening layer serving to give depth and tone to the lines, which may be made fine or coarse by using suitably pointed tools. In this manner letters may be written and sketches or drawings executed very rapidly and with great facility.

The next step is to place the prepared plate in a level position and to pour over it a quantity of plaster of Paris, of which the matrix over which the stereotype or electrotype afterward to be made is formed. As soon as the plaster is sufficiently hardened or set, the matrix is removed from the bed plate. This may be easily accomplished by slightly heating the under side of the plate, thus melting or softening the intervening layer, when the tinfoil, with its plaster backing, may be readily removed.

The face of the matrix (which is formed by the tinfoil) is now washed with benzine, turpentine, or other material, for the purpose of removing any portion of the intervening substance which may still adhere, and the matrix is now ready for stereotyping or electrotyping.

By drawing in the tinfoil with suitable tools, lines may be obtained as clear and sharp as the finest line engraving, the intervening layer serving not only to hold the foil upon the bed plate, but to give depth, tone, and richness. Its thickness may therefore be varied to suit circumstances.

To obtain correct likenesses of individuals, scenes from nature, etc., such likenesses are to be photographed upon the tinfoil, to serve as a guide for the draughtsman, whose task is thus reduced to a mere mechanical one.

By this process printing blocks of any subject may be produced with great rapidity and accuracy, and at a trifling expense.

(*b*) First provide a bed or base plate of steel or other suitable material that will resist heat, the top of which should be polished smooth and placed in a perfectly level position. Next, provide the plate with a coating of plastic material which will resist heat —such as slaked lime, kaolin, or tripoli, which, when mixed with a suitable quantity of water, will form a plastic composition which may be spread evenly upon the top of the plate to form a coating of uniform thickness, and which will not melt or "run" by the application of heat.

The next step is to carefully cover the coating with a layer of foil which will not melt at the temperature where type-metal melts. Thin copper foil is well adapted for this purpose, and this should be provided with a thin film or coating of tin or solder. As thus prepared, the base plate is ready to receive the engraving by indenting the foil, down through the layer of plastic material, to the base by means of a stylus or other suitable instrument, according to the figure, sketch, or lettering which it is desired to represent in the engraving. The plastic layer operates to give depth and tone to the lines, which may be made fine or coarse by using different kinds of tools; and it will readily be seen that as the engraver has soft and yielding material to work in, the engraving, or rather indentation, may be executed with great rapidity. The plate having been prepared, the thin film or coating of foil is carefully moistened with muriatic acid, to prepare it to receive and firmly adhere to the type-metal backing. The plate is placed in a frame, after which a quantity of molten type-metal is poured over the foil to form a plate or backing of the desired thickness. The type-metal, as it flows freely over the foil film, unites therewith without disturbing in the least the underlying foil or coating, and after hardening, the plate or relief block thus formed is removed from the coated base plate and is ready for use, after washing its face to remove any trace of the coating material, and suitably finishing the back.

Glass.—Planté has suggested a process for engraving on glass by electricity: The plate is covered with a concentrated solution of potash nitrate, put in connection with one of the poles of the battery, and the design is traced out by a fine platinum point connected to the other pole. The results are said to be of wonderful delicacy. Round articles can be treated by adding gum to the solution to make it adhere.

* * *

ETCHING.

(*See also* ENGRAVING GLASS, PROCESS-ENGRAVING, ETC.)

THE subject of etching is very closely related to that of engraving, so closely that in some branches of the engraver's art, his works are either commenced or carried forward by the aid of etching.

Materials and Appliances.—The appliances required consist of copper plates, etching needles, hand-rest, a substance called etching-ground, a dabber, oil-rubber, some rotten-stone, a smoking taper, engraver's shade, bordering wax, stopping-out varnish, tracing-paper, and the etching fluid, aquafortis (nitric acid).

Ground.—The ground is composed of equal parts of asphaltum, Burgundy-pitch, and beeswax ; place them in an earthen pipkin in an oven, and melt. The mass must be kept stirred until well incorporated. Pour the mixture into a basin of cold water, and, when nearly cold, press and roll with the hand until all the water is discharged, then make into a ball. Procure a piece of worn silk, without holes ; double it ; place the ball therein, and tie up the ends with packthread, taking care that the double silk reaches well and tightly over the ball ; cut off the surplus silk, and let the knot remain for a hand-hold.

Dabber.—Take a piece of silk, twice the size of that for the ground ball ; double it ; place it in a ball of coarse wool well picked out, about the size of a small apple ; tie it up in the same way as the ball for the ground, and it is ready for use.

Oil-rubber.—An oil-rubber is made from a strip of woollen cloth, about 2 in. wide, rolled up tightly, and bound over with packthread or thin tape. With a sharp knife cut off one end, avoiding the string, so that the surface may be quite flat. This is used for taking out stains, or polishing the plate, as in Fig. 96.

Rotten-stone.—Take a piece of fine flannel, rather less than the silk which covers the etching-ground ball ; double it ; place on it a small quantity of rotten-stone, in powder, which tie up in a bag. A small portion of fine whiting in the lump should be also kept at hand.

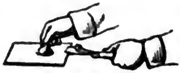


FIG. 96.

Smoking Taper, or Lamp. — For small plates, procure a wax taper ; uncoil it by degrees before the fire until it is all equally pliant ; double it up in about six lengths ; give it one twist while warm, and turn it a few times before the fire, that the pieces of taper may adhere to each other ; melt the wax at one end, so that the wick is exposed ; see that all the cotton ends will light freely ; care should be taken to extinguish the cotton, or it will revive with the least draught, and may become dangerous. For large plates it is preferable to use an ordinary oil lamp mounted on gimbals ; this obviates the inconvenience occasioned by the dripping of the tapers.

Bordering Wax.—3 oz. rosin, 2 oz. beeswax, and such a quantity of sweet oil as will soften the mixture to fancy. Procure an earthen pipkin ; place in the bottom ½ oz. or more of sweet oil ; add the rosin and beeswax, broken in small pieces ; when melted, work the ingredients well together with a stick until thoroughly incorporated ; then pour into a basin of cold water ; as it gets cold, work it well with the hands by pulling out into lengths and doubling it together again ; the more it is worked the better it will be for use. Should it turn out brittle, return it broken to the pipkin, and add more oil ; work it well together as before, pour it into water, and work it again with the hands.

Engraver's Shade.—Bend a piece of

wire into a half-circle ; bind it together with waxed string ; lay it on tissue paper ; cut away all but ½ in. round the wire : cover that ½ in. with paste, and turn it over the wire ; when dry the shade is complete. Fasten a light string to the centre of the half-circle, and suspend it from the window-latch when in use. This shade must be placed in a forward position, sloping before the plate, and the white light it produces will enable the engraver to see the lines made by the etching needle. An equally effective shade may be made by covering a light square wire frame with tissue paper, and supporting it with two struts. This frame can be made to rest at any angle, upon the table immediately in front of the work.

Hand-Rest.—Any flat and thin piece of wood will answer the purpose, which is to keep the hand clear of the plate whilst at work. A good hand-rest may be made of a thin board raised above the work upon side pieces of such a height as to allow the plate to be freely moved underneath the board. The front edge of the board may be faced with a strip of steel planed true, when it serves as a straight-edge. This arrangement will be found extremely handy.

Stopping-out Varnish.—Turpentine varnish is superior, for several reasons, to Brunswick black.

Turpentine Varnish.—Break small pieces of rosin into a phial ; pour over spirits of turpentine to about twice the height of the rosin. Place the bottle in a small saucepan of water on the hob, near enough to the fire to make and keep the water hot ; place a cork lightly in the mouth of the bottle, as the mixture will require to be shaken occasionally. Pour a small portion of this mixture into a small pot, with a little lampblack added to give it a colour, and well mix. This last is necessary to prevent lumps ; it may be done by working the mixture well together with the camel-hair pencil. This is a good stopping-out varnish. With this varnish go over the border or margin of your plate ; do this when about to put it away, and the varnish will become hard by being left a night to set. When biting-in again, go over the margin, using the same brush and mixture. It can always be worked up by adding a little turpentine. When it is set so hard that the finger may be placed on it without sticking, it is time to make up the wall or border of wax to hold the aquafortis.

Aquafortis.—Procure three half-pint bottles with glass stoppers, and two pint earthen jugs with spouts. Place ½ lb. of nitric acid in bottle No. 1. Pour into bottle No. 2 rather less than the fourth of the nitric acid ; fill the bottle ¾ full of water ; slowly pass it into one of your pint jugs, and back again to the bottle, to mix it well. In bottle No. 3 put one-half of the remaining nitric acid ; water it as before ; see that the nitric acid in bottle No. 1 is well stoppered, and cover it with a piece of old glove.

Tracing and Tracing-Paper.—Tracing can be conveniently effected by using sheets of transparent gelatine, similar to that made for Heliotype purposes, and placing it over the drawing, which can be seen clearly through the gelatine. Trace with a sharp etching-needle, taking care to remove the burr from the lines with the thumb-nail as the work proceeds. When finished, fill in with fine powdered Brunswick black, entirely free from grease, or powdered red chalk, reverse on to the plate, and rub the lines with a burnisher. Tracing-paper of various qualities may be readily purchased. But in case of necessity, very good tracing-paper may be made by saturating, with a camel-hair pencil, the finest tissue paper with the following mixture : ½ oz. Canada balsam to ¼ oz. spirits of turpentine ; shake well together in a 2-oz. bottle. When covered with the mixture, hang the paper on a line to dry ; then wash in like manner the other side. Place your drawing on a tracing-board—a piece of soft planed deal ; lay the tracing-paper over it ; fasten down with brass-headed points, not through the drawing, but close to it, so that the pressure of the brass head secures both the drawing and tracing-paper from moving. Go carefully over all the lines of your drawing with an H pencil, occasionally placing a piece of white paper between the drawing and the tracing-paper to ascertain that no lines on the drawing have escaped attention.

Transferring Paper.—This is made as follows : Take half a sheet of very fine bank-post paper ; lay it on a clean place, and rub it well with the scrapings of red chalk with a small piece of sponge. Apply the chalk until the paper is all of one colour ; then, with a piece of clean old muslin, rub the greater part of the colour from the surface. The colour may be renewed occasionally as the markings become faint.

Processes.—*Testing the Ground.* Heat one corner of your plate, and rub over it the ground in a thin and even surface. Next apply your dabber, to make a yet more equal distribution of the ground. When cold, mark over it with rather a blunt needle (No. 3). Should the ground be brittle, and crack with the passage of the needle, add to it more beeswax ; should it drag with the needle, add more asphaltum ; the ground will easily melt again. When a ball is satisfactorily made, it will last a long time. The weather has considerable effect on the mixture, and the quality of the ingredients is very important, so that it is advisable to get the ground as perfect as possible while the melting pot is in use.

Heating the Plate for Ground.—Have a small hand-vice, Fig. 97, with a haft of wood to resist the passage of heat to the hand. If the plate is stained or discolored, the mark must be removed with the oil-rubber with a little rotten-stone and oil, polished off with a bit of old muslin powdered with whiting, care being taken that no dust remains on the plate. Screw the vice on the long side of the copper plate with a slight hold, covering the part grasped by the jaws of the vice with a small piece of paper to prevent injury to the surface. Heating may be performed by burning paper under the back of the plate ; but a stove or clear fire is preferable, and a couple of spirit lamps with rests for the corners of the plate, the best plan of all. Be careful not to overheat the plate. If the surface becomes discolored, the plate is overhot ; as a test, turn it over, and spit on the back ; if the moisture jumps off, the plate is sufficiently hot ; should it hiss, and remain on the plate, more heat must be obtained. A piece of canvas, rather larger than the plate should be warmed by laying it before the fire during the heating process ; place it on the table, and lay upon it the plate retained in the vice. Now pass the ball of ground, Fig. 98, over it backwards and forwards until the plate is covered, spreading the ground as evenly and thinly as possible. Use the dabber with a quick action, pressing it down and plucking it up. If the ground does not distribute itself easily, burn paper under the plate as before until it shines all over, being cautious that the ashes of the paper do not settle on the surface ; dab on again, decreasing the pressure, but not the speed of action, until the surface is all over alike.

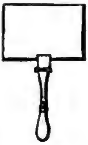


FIG. 97.

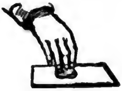


FIG. 98.

Smoking the Plate.—Have the taper ready, and a single taper or candle to take the light from ; the surface of the plate being perfectly covered, it may be as well to renew the heat in the plate, by a paper burnt under the back until the surface shines, taking the same precautions as before. Hold the plate in the left hand, with the face downward ; light the smoking taper, Fig. 99, at the same time, having all the wicks burning; pass it rather quickly round the margin, and by degrees towards the centre, using a fluttering action with the hand, Fig. 100; smoke on until the whole surface is of a dark colour, keeping the taper at such a distance from the plate that the burning cotton may have no chance of touching it, although the flame spreads over it. Another way is to suspend the plate, if of large size, overhead, and smoke with the oil lamp. When the surface is all black alike, and no sooty marks are to be seen on the working part of the plate, the ground is fit for use. Take the plate, face downwards, to some convenient place, and pour cold water over the back, Fig. 101, holding the plate in a sloping position, the vice up. This last process produces a stronger and harder surface than could be obtained if the plate were left gradually to cool. Now place the plate face downwards, supported on one side by the screw of the vice, Fig. 102. Clean the smoke from the back, and let it remain until quite cold. Some difficulty may be found in laying the first ground with success, but with a little practice this is surmounted.

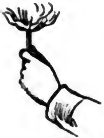


FIG. 99.

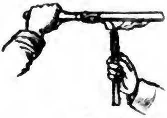


FIG. 100.

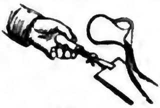


FIG. 101.

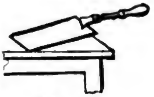


FIG. 102.

Transferring.—In the absence of an etching-board, place the copper plate on a thick piece of brown paper larger than the plate; make two ribs of the same paper, doubled four or more times and about an inch wide; place them at each end of the plate on the brown paper, and fasten them with sealing wax; these ribs serve as shoulders for the rest to lie on, which will prevent the hand from touching the work. Now cut the tracing paper to the size of the plate, having ruled the margin line if one is required. Place the tracing reversed; that is, with the pencil side to the plate. Fix it with pieces of soft wax round the border, leaving open the bottom to admit the transfer paper, which introduce with the chalk side next to the plate; the upper side of the paper must be kept clean, that the pencil-lines on the tracing paper may be seen. With an H H pencil, cut sharp and short, go over all the lines of the tracing with rather an upright hand and a strong pressure; the upper side of the tracing-paper will show whether all the lines have been traced; look sideways at the work, and the black-lead marks will be perceptible. Before advancing far in the transfer, lift up the bottom of the tracing to ascertain if the lines are of sufficient strength; if not, apply more red chalk to the transfer paper. When the transfer is nearly completed, do not take off the whole of the paper, but let the top part remain fixed. Then lift up the tracing, and if any part of it has been neglected, it can again be fixed down, and the omission rectified.

Etching.—Commence with a fine-pointed needle, No. 1, and go carefully over the outline, not making much impression on the copper, but sufficient to remove the ground; with the same point go over all the lighter parts, increasing the pressure, so as to make a slight indentation on the plate. No. 2 point may now be used to go over the lighter shade, with an increased weight of hand. No. 2 point will answer for the darker shades by making the lines nearer together and increasing the pressure. Interline parts that require extra colour with No. 1 point; the etching may be worked at for a considerable time by interlining and dotting. If there are any marks to expunge, dip a pointed camel-hair pencil into the turpentine bottle, and with its point work up some of the ground on the margin of the plate, and therewith stop out the objectionable marks. When set, it will resist the aquafortis.

Bordering the Plate. — In cold weather the wax will be too hard to roll out with the hand; in that case it must be placed in moderately warm water until it becomes pliable; then pull, and roll it out, Fig. 103, to about the thickness of a small walking-stick; slightly grease the point of the thumb and two forefingers with mutton fat; press the roll of wax flat, and place it on the border of the plate with the edge to the varnish, taking great care that the bordering wax does not go off the varnish. At the parts intended to be the darkest corner of the plate, pinch out the wax border, that the height of the wall may be increased at that corner where the spout is to be formed with the wax to prevent spilling the aquafortis in pouring it off.

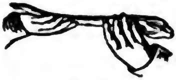


FIG. 103.

Biting-in.—Lay the plate flat on a piece of canvas larger than the plate, as a protection from any splashings that may be made. Place the spout of the plate in front for the convenience of pouring off. Pour a little water over the plate to see if there are any leaks in your border; if there are any, pour off the water; let the plate dry, particularly in the defective part; then press down the outer edge of the wax with a piece of wood. Leaks can also be found without using water by holding the plate up to the light and looking at the edge, when the smallest pin-hole will be immediately detected. Have two or three small wedges, to be used for tilting the plate should the acid not lie even. When the border is sound, pour off the water; then cover the surface of the plate with the aquafortis from No. 2 bottle. If, in the course of half a minute, the etching on the plate should assume a light-grey coating, the mixture is good; but if it should throw up bubbles, it is over strong, and more water must be added but not on the plate. The mixture must be placed in the jug, then in the bottle, and afterwards returned to the plate. Should the lines on the plate remain as bright copper after the acid has been on half a minute, it is not strong enough, and some aquafortis out of bottle No. 3 must be added. When the mixture on the lines does not produce a foam, but the plate continues of a grey, frosty appearance, the process is going on well. The power of biting-in correctly depends on the experience in using the acid. With a soft camel-hair pencil, lightly remove the frosty appearance, taking care that the quill does not touch the ground. Should any part of the ground break up by the lines becoming united, pour off the acid carefully into the jug. Lay the plate again on the flat, and cover it with water from the other jug, moving it gently with the camel-hair pencil, which place at once in a water jug when taken from the acid, or it will soon be destroyed. Throw away the wash water from the plate. When the first biting is completed set the plate up endways to dry, Fig. 104.

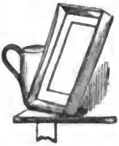


FIG. 104.

Second Biting.—When the plate is perfectly dry, take off with a blunt point covered with silk and dipped in turps a spot of ground in the lighter part to ascertain if the acid has made sufficient indentation. If it has, work up the stopping-out varnish with a camel-hair pencil, and with it cover all the parts intended to remain light; elevate the rest, Fig. 105, so as not to press the border wax. When the stopping-out varnish is dry, which may be ascertained by placing the finger on it (if it does not stick, it is dry), put on the same aquafortis (bottle No. 2), and let it remain until you observe the ground giving way; then pour off the acid, and wash well as before. Put the plate to drain. Should it be required, more biting may be done; the process is the same.

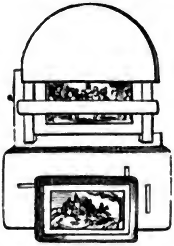


FIG. 105.

Cleaning Off.—Great care must be taken that the plate is perfectly dry; if it is not, it may be placed before the fire, but not close enough to melt the wax. Having carefully wiped the canvas, lay the plate a little more than half-way upon it, so that the balance remains upon the table. Apply a lighted taper, or a folded paper match, progressively under the wax; pull up the wax, Fig. 106, as the warmth proceeds; a very slight warmth answers the purpose. By removing the wax with a knife you are liable to injure the margin, which is difficult to remedy. Should any of the wax adhere to the plate, remove it by using a piece of wood cut in the shape of a chisel. Fix the vice on the same place as when laying on the ground. Rub the plate over with turps, taking care to go over every part: hold the plate up by the vice; heat the back with burning paper as before, until the ground varnish and tallow are melted. Rub off with a soft rag. Should any smut remain, apply a little turpentine; withdraw the vice, and wash the spot it covered with turpentine. Rub the plate front, back, and sides with the rag. Dab the plate with the bag of rotten-stone; pour on it a little sweet oil; and polish the plate with the oil-rubber, using considerable up-and-down pressure; wipe the plate quite clean, and polish with fine whiting. Should the biting-in have succeeded, the plate is ready for the printer.

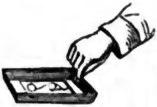


FIG. 106.

Dry Point.—The dry point may next be used. For this purpose the needle No. 3, well pointed, may be employed, as indenture must be made by pressure of the hand. For interlining the parts which are too weak, and uniting lines neglected in the etching, the dry point will be sufficient; but the pressure will leave a projection or burr on the plate, which must be carefully removed by the sharp scraper; should the plate require more than the dry point can accomplish, recourse must be had to re-biting.

Re-biting.—Heat the plate as before, but make one corner, the one with the least work in it, hotter than the other part. Prior to laying the ground, the plate should be polished with whiting, or with methylated spirit and aquafortis, using a piece of old muslin folded in the shape of a dabber, which will fill the etched lines, and prevent the new-laid ground from entering. Rub the ground on the hot corner, and with the dabber take the ground therefrom, and dab quickly over the other part until the whole surface is covered. All the parts but those wanting more colour may be stopped-out as before; the border wax must again be used. Next follow the same process with the acid.

Re-etching.—This is the most certain method of finishing the plate. The ground must be laid as in the first instance, but using a greater body, and with the dabber, Fig. 107, rubbing it well into the lines, taking care that no whiting remains in the etching marks; for this process the plate should be merely washed with turpentine; a slight extra warmth and good dabbing will render the ground acid proof. The smoking is here dispensed with. Set up the ground, and work at the plate as in the first instance. Now use No. 3 sharp point, and interline the parts that should be darker and where greater strength is wanted, crossing the lines, not at right angles, but lozenge-ways. The plate, cleaned off as before directed, receiving a light oil rubbing with a little rotten-stone, and washed off with turpentine, may now be sent to the printer's, and a proof obtained. By repeating the re-etching, the plate may be worked up to the colour of a line engraving. In some of the darker parts a graver or lozenge-tool may be used; but it is rather dangerous in the hands of the uninitiated; as it is apt to slip, and make deep lines where none are wanted. Re-biting will produce any extra colour that may be wanted, with little more trouble and with greater safety.

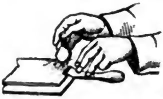


FIG. 107.

Process avoiding Stopping-out.—For the first biting, ground, and smoke the plate in the ordinary manner, then etch those parts only which are to be darkest, such as vigorous foreground in landscapes, and other deep work. Use no delicate lines at this stage; japan the back of the plate and the spot where the hand-vice was placed; use a photographer's tray as an acid bath, in which immerse the plate in nitric acid until the very black lines are bitten-in. Clean the plate, and take a proof. For the second biting, ground the plate again, and smoke it; the first lines will still clearly show. Draw all the work of a medium darkness, with a sharper point than that used for the first biting-in. Place the plate in the acid bath, and let it remain until the lines are of a moderate depth. Remove and clean the plate, and take a second proof. For the third biting, ground with transparent ground, and do not smoke it. Etch all the delicate work, keeping the lines close to each other, and using a sharper needle than before. This operation requires more care than the two previous ones, as the lines will not show very distinctly. This process is of great service for intricate work, in consequence of the facility it gives for introducing pale lines amongst the darker work, and a delicate background beyond the vigorous lines of the subject; whilst, by taking proofs after each biting, the progress of the work may be seen, and its correctness ensured. By covering the back and edges of the plate with japan varnish, the old and tedious process of banking up the sides with wax is avoided, and the plate may be plunged into the acid bath without any further risk or trouble.

General Instructions.—The following directions will relieve beginners from much trouble, and enable them to avoid many accidents to which engravers are liable: When using the acid, slightly grease that part of the hand likely to come in contact with it, as a preventive to its making stains, which are not easily eradicated. When your border wax has done its duty, have it well washed in cold water, then warmed before the fire, pulled out and pressed together again, as the more frequently that is done the more pliable the wax will be for future use. As your aquafortis will become reduced in strength by exposure to the air, it becomes necessary to add a portion of No. 3 bottle to that of No. 2, and a small quantity of No. 1 bottle to No. 3, No. 1 bottle containing the undiluted acid. When making a point to an etching needle, work the point round, as, should there be any flat side to the point, it will bite the copper, and prevent the freedom of hand required to give spirit to the etching. The burnisher will soften down any part of the etching that appears harsh or crude, by gently passing it over the parts to be reduced in colour. The shade must be between the plate and the light, in order to be able to see the marks of the burnisher ; fine charcoal and oil will remove these marks, and the oil-rubber will clear away the charcoal marks. The charcoal can be obtained at a coppersmith's or plate-printer's. If a burnisher is good at first, it never requires alteration. The scraper must be occasionally sharpened.

Soft Ground.—Take half a ball of hard ground, mixed as described under the head *Etching Ground* ; to that add a piece of mutton suet. Melt them well together, observing that the ingredients must be thoroughly incorporated ; then pour into cold water, and use it as before directed.

Laying the Ground.—The process is exactly the same as in laying the etching-ground, with this difference, that the plate does not require so great a heat. Smoke the plate the same as in laying etching-ground. The ground must be spread as thinly as possible, to cover the plate and bear smoking. The surface of the plate must be alike all over, and quite bright or shining. If any part but the edges appears sooty, it must be cleared off, and the plate polished, as described for etching, and laid again. A good ground may be made at the first melting, but that can scarcely be expected. It may be as well to test the quality of the mixture before laying a whole ground. To this end, heat a small portion of the plate ; lay on the ground ; smoke it ; and let it get quite cold. Obtain some of the finest tissue paper, of very even texture. Place a piece of the paper on the patch of ground laid, and, with a fine-pointed H pencil, make a slight sketch—a bit of foliage, for instance ; the paper should slightly stick to the plate ; when carefully raised by the two bottom corners, the back of it should clearly show every line made on its surface, only darker. Should the sketch on the copper look as if it was dotted all over, the mixture of ground will do. Should the ground adhere to the paper, like marks with pen and ink, the ground must be melted, with an addition of hard ground ; and if even the softest marks of the pencil do not pull the ground from the plate, the ground must be remelted, and remixed until it is fit for work. As the temperature has great effect on this ground, that which will answer for summer will not do for winter, so it may be as well to make two or three mixtures, and number them according to their several degrees of hardness. Having succeeded in mixing the ground, take a piece of tissue paper twice the size of the plate. Place the plate in the centre, and with a black-lead pencil draw a line all round it. Make the same mark on the other side ; then lay the ground as described. When cold, wipe the back and edges before taking off the hand-vice. This ground being very tender, care must be taken not to touch the face of the plate.

Drawing.—The drawing is to be made upon the square marked on the paper. If it is intended to copy a subject, the same process as in transferring for the hard-ground etching is used ; only, instead of transferring the red lines on to the plate, they must be made within the square marked on the paper. Take care that the tracing is reversed. If it is intended to draw on the plate without copy, lightly make the design on the square marked with fine-pointed red chalk. Should the subject be figures, everything must be drawn to the left hand, or reversed. Fold a silk handkerchief in four; lay it flat and smooth on the table ; place on it the paper, with the chalk sketch downwards. Then, with great care, lay the plate, face down, exactly on the square mark of the paper ; fold over the back the surplus paper, and fix the sides with four thin spots of sealing wax near the corners ; be sure not to move the plate on the silk. Take up the plate carefully, and place it for work. Use a hand-rest, as in etching, and a hard pencil, H H, on the places you wish to be dark. In soft-ground engraving, the drawing must be finished the day it is commenced; the mechanical part of the work may be delayed. When the drawing is finished, pull up the paper by the two bottom corners. Varnish the border down the same as in etching. The acid used must be much stronger; the border wax higher and broader in the spout, as you may perhaps have to pour off suddenly.

Biting-in.—In biting-in, pour off the acid when the ground begins to break up; that is, coming up in patches. During the biting-in, the soft camel-hair pencil may be used, but very tenderly. Wash well off with cold water, and place the plate to dry. For cleaning, see *Etching.* Should the plate require more finishing, have recourse to the hard ground without smoking.

Aqua-tinta Engraving.—This was formerly resorted to where the object was to produce a plate, the impressions from which were to be coloured. It is recognised by its similarity to Indian ink or sepia drawing; for, in working the plate at press, black and brown inks are used indifferently, as the artist or publisher may direct. Rosin forms the ground in this method of engraving.

Aqua-tinta Ground.—Break some of the best white rosin into pieces, put into a bottle with spirits of wine, and shake occasionally until the rosin is dissolved. The bottles must have corks, not glass stoppers. Have two other bottles ready; mark the bottles 1, 2, 3. No. 1 is the bottle in which the rosin is placed. Pour a third of No. 1 into No. 2, and nearly fill it with spirits of wine. Pour into No. 3 rather less of the mixture from No. 1, and nearly fill it with spirits of wine. These bottles must be occasionally shaken, and their contents allowed to settle well before use. The contents of the three bottles must be so mixed that they are one under the other in strength, as the size of the grain to be laid on the plate depends on the quantity of rosin each mixture contains. The more rosin the larger the grain. The spirits should be entirely free from water.

Testing the Spirits.—Place a small quantity of gunpowder in a silver spoon; pour over it some of the spirit; light the spirit, and let it burn to the powder. If the powder takes fire and explodes, the spirit is good, and fit for use. Should it remain in the bottom of the spoon, black and wet, the spirit has been adulterated with water, and is not fit for the purpose.

Trial of Aqua-tinta Ground.—Have a tin trough about 2 in. wide, and rather longer than the plate, with a convenient spout at one end; the trough is to act as a receiver of the spirit when poured over the plate; the spout to return it to the bottle.

Laying the Ground.—Polish the plate well, as before directed. Place it at a slight slope, the tin trough under the lower edge to receive the spare mixture. As a trial of the ground, pour the liquid from each bottle, and make a small patch in different places at the bottom of the plate. When the liquid has run off into the tin trough, lay the plate flat, and with a piece of rag wipe the lower edge. Take a magnifying glass, and look at the grains deposited on the copper. Having poured the spirit from the trough to bottle No. 1, make choice of the grain most likely to suit the work; if neither of the three should, mix the large grain and the small together until it does, letting the mixture settle well before it is used. Remove the trial spots; polish the plate well, and place it as directed for trial with the side intended for the foreground next to the tin trough. Pour the mixture along the top of the plate, from one end to the other, until the whole of the surface is covered. As soon as the spirit has run into the tin, lay the plate flat; the sooner it is laid flat, the rounder will be the setting of the grain; the longer the plate remains on the slope the more elongated the deposit of rosin will become, which for some sort of work will answer better than round; such as broken rock, waterfalls. In most cases it is advisible to make a very fine etching of the subject intended to be placed on the plate prior to laying the aqua-tinta ground; in the end it will save time. The etching must be very light, otherwise the aqua-tinta ground will hang round the lines, and form a ray of light. Should the etching be strong, it will require to be filled up with wax, and polished off before laying the ground. Engravers send the plate to the printer's to have it filled up with ink, which is the best method. If obliged to use wax, heat the plate rather above what is required for the etching-ground; the surface is then wiped off, and polished with the soft part of the hand slightly rubbed with whiting.

Stopping-out the Lights.—Place on the left side a small looking-glass in a leaning-forward position; lay before it the drawing intended to be worked from, with the base or foreground towards the bottom of the glass; you will then see the subject reversed in the glass. Go over the margin as directed in the head *Etching*. For this a camel-hair pencil and the same pot of varnish, with a little more lampblack added, and well worked together, should be used. Stop out all the white lights seen in the drawing. By the time this is done, the varnish on the margin will be dry or set; if not, the plate must remain until it is. Go over the margin again with the same varnish, and let that set hard. Place your border wax as before directed, making the spout rather larger, that you may be enabled to pour off the acid quickly if necessary. Use the same aquafortis as for etching, but the strength somewhat increased, as it must remain on the plate a much shorter time. Lay the plate an inch or so over the front of the table, with a piece of canvas underneath, having small wedges of wood ready to be used should the acid not float evenly.

First Lights.—Pour on the acid rather quickly, running it from the bottle to the jug, then on to the plate; another jug, having been filled with cold water, should be kept ready for washing off. When the acid has entirely covered the plate, the surface should immediately assume a frosty appearance, but not come up in bladders. Little more than a minute may be enough for the acid to remain on the plate; pour it into the jug as quickly as you can without spilling it; immediately wash off with cold water; have a receiver for the wash-water, as it must be thrown away.

Second Lights.—Dry the surface of the plate, and, should any spots of moisture remain on the surface, carefully take them up with blotting-paper. Now, with the same varnish, stop-out all the second lights. To prevent injury to the border, place two blocks or old books under the ends of your rest.

Third Lights.—When the second stopping-out is set, put the plate through the same process with the same acid. Again dry the plate, and stop out the third light parts; when set, apply the acid, but let it remain on rather longer; wash as before directed. As all the flat tints are now laid, it only requires the very dark ones. Ascertain, with a magnifying glass, if the spots of rosin remain on the plate; if so, it will bear biting again. Should the ground remain sound enough to stand another application of the nitric acid, you must prepare a mixture called touching stuff.

Touching Stuff.—Burn a good-sized cork to ashes; take some treacle and add as much ivory black as will make the mixture a dark colour by the addition of a small quantity of sheep- or ox-gall; it works almost as free as the varnish. Make the composition into a ball, a small quantity to be used with water when required. Again lay the plate for work. Paint over all parts that are required to be very dark, such as projecting foliage, and all sharp shadows, with the touching stuff, loading all the touches with as much of the mixture as can be placed on them. When the touching stuff is dry, mix some turpentine varnish, slightly coloured with lampblack, and with a larger brush go over the whole of the plate. When this last varnish is set, pour on some very weak acid and water; the former washings of the plate will do. With the soft camel-hair pencil used for the acid, work up the touching stuff until the whole comes off; then wash the plate clean with cold water, and again apply the acid. For this last biting the acid may remain on the plate as long as the ground will stand. This may be ascertained by clearing the plate with the camel-hair pencil, and using the magnifying glass. The plate must now be cleaned, and remove the border wax as before described. On this tint the oil-rubber should be very carefully used. The plate being quite clean, and placed under the shade, it will be found that the tints or bitings are rather sharper against each other than is required. The burnisher will remove this by rubbing the parts which are to be reduced in colour. The parts to be burnished should be slightly touched with the oil-rubber. The use of the burnisher requires some skill, which can only be acquired by practice. The scraper is useful for bringing out sharp lights, and modulating the darker parts. If the first ground is not satisfactory, the plate must be polished, and another ground laid. The second ground must contain more rosin than the first; bordering, biting, and stopping-out, as before. The plate should be sent for proof before the second ground is laid. The proof will show where increase and where reduction of colour is required. The burnisher will reduce; the increase can only be had by laying another ground.

Ground to Etch on.—Mix a small quantity of turpentine varnish with turpentine slightly coloured with black, but only sufficiently so as to render the lines made by the needle perceptible. With this thin varnish, and a good-sized camel-hair brush, go over the plate lengthways; when that is set, repeat the coating crossways; let it set, and lay it by for a night if convenient. The etching finished, border and bite as before directed, but with stronger acid.

General Instructions.—Great care must be taken while laying the ground that there is not much dust floating in the air; for, should the slightest particle of flock lodge on the plate whilst wet it will cause what is called an accident. Wherever the speck falls, the rosin will corrode around it, forming a white spot on the ground where the acid has been applied. These accidents are of little consequence, unless they should happen on the sky. To do away with these light places, the chalk tool, or dotter, must be used; this is simply a bent graver. From pouring the ground mixture backwards and forwards, it is likely to become foul; it should then be passed through a double piece of clean muslin, and put away in a bottle to settle. The burnisher acts as principal in forming a good sky and background. As the action of the acid will leave all the tints with a sharp edge, they must be softened down with the burnisher. Every fresh aqua-tinta ground laid should be increased in the size of the grain, or the ground will become murky. To enrich and darken the foreground and foliage, etching over the parts with the etching-ground above described is much the easiest method.

Rosin-Ground Etching.—This is well adapted to ornamental work, as great depth of colour can be obtained. The process is extremely simple. The best white rosin should be reduced to powder by pestle and mortar, then placed in fine double flannel, and tied up in a bag. The plate must be heated as in laying etching-ground, and the rosin then powdered on the surface; lay the plate on a table, so as to leave both hands free. Take the bag of rosin in the right hand, and strike it against the left. The bag must be held some distance from the plate, which will force the powdered rosin to escape from the flannel bag, and, falling on the hot plate, will there fix itself in small spots, something similar to the aqua-tint deposit, but much more enduring. This produces very imperfect results, and causes dry-ground engravings to be looked on with disfavour. The stopping-out process is the same as in the aqua-tint. By repeating the process with the flannel bag, a positive black ground may be procured, as dark and more enduring than a mezzo-tinto ground, and it may be scraped on much in the same way.

Hamerton's Brush Process.—This process consists in the employment of a pigment which is strongly attacked by acid. Clean the plate thoroughly with whiting and turpentine. Remove the whiting by rubbing the plate with bread; after removing which do not allow the hands to touch the plate. Crush a soft pastel into fine powder; mix with a strong solution of white sugar. Add a solution of ox-gall, about equal in quantity to half the sugar solution. The pigment must be so mixed as to work rather freely, and draw a thin line with ease and precision. With a small, fine-pointed sable-hair brush, make the drawing on the plate, depending mainly upon lines, as with a pen; when this is completed, be careful not to let anything touch the plate, as the pigment dries slowly. Dissolve some ordinary etching-ground in ether; hold the plate with a pneumatic holder, and pour the solution upon the plate till it makes a pool reaching the sides of the plate; move the plate gently from side to side, then pour the superfluous solution back into the bottle. Heat the plate gently over a spirit lamp, holding it about 12 inches above the flame, and taking care to evaporate the ether gradually, and not to allow it to catch fire. The ground will become transparent. Place the plate in a bath consisting of 100 grm. hydrochloric acid, 20 grm. chlorate of potash, 880 grm. water. The hydrochloric acid used should not be of a deep yellow colour; should not give off fumes, and, when mixed with water, should have but a slight odour. Leave the plate in this bath ¼ hour, then brush the surface of the plate very gently with a feather. This will remove the pigment and the ether varnish over it, leaving the lines exposed to the acid. The copper between them will be perfectly protected. Leave the plate in the bath until bitten-in to the required depth, stopping-out when necessary. The finer portions of the work may either be finished with the dry point, or in point etching; in the latter case using a transparent ground. If any erasing is necessary, it must be done with a scraper. If the pigment does not take on the plate, the copper may be slightly roughened by a short immersion in a weak nitric acid bath. Let the ether ground remain a night on the copper before heating it which must be very carefully done.

Hamerton's Negative Process.—This process avoids stopping-out altogether, and the progress of the work may be judged of with tolerable certainty. The ground is a solution of beeswax in turpentine. Decant the solution till no sediment remains; it should be perfectly fluid, and of a bright yellow colour. Add about one-sixth of its volume of japan varnish; this quantity will vary slightly according to the heat of the weather. If there is too much japan, the ground will be hard and brittle; if there is too little, it will not be strong enough to take smoke with safety. Clean the plate with engravers' emery paper, and place it in a bath of 100 grm. hydrochloric acid, 20 grm. chlorate of potash, 880 grm. water. When the plate darkens all over, it is a sign that there is no grease on it, and it is then ready to receive the ground. Pour on the ground as photographers pour collodion, and let it dry for 12 hours; apply a second coat of ground in the same manner, and smoke the plate immediately without waiting for it to dry. The ground should then be even and smooth, and ought to be used a few days after it is laid, as it hardens in time. If in haste to use the plate, the first coat of ground may be dried over a spirit lamp until it becomes transparent; cool the plate, and proceed as before described. The use of the two coats of ground is to prevent the smoke penetrating to the plate, and causing the ground to become detached in the acid bath. Should the ground be too hard, increase the proportion of the wax solution. Draw all the dark parts first; plunge the plate into a bath of nitric acid for half the time necessary to complete the biting. In temperate weather this would be half an hour; the first biting would, therefore, take about 15 minutes. Remove the plate, dry on blotting-paper, draw the next darkest lines where required, and replace the plate in the bath for a quarter of the total time. This process is repeated, and the plate, with the paler work, is replaced in the bath for one-eighth of the total time. The palest work of all is last drawn, and the plate is plunged into the bath for an eighth of the total time. Thus the plate will have had the darkest lines in acid the whole time required, the darker lines half the time, the pale lines a quarter, and the palest lines one-eighth of the time, as each biting in has the advantage of those which preceded it. Finish with the dry point where required.

Hamerton's Positive Process. By this process the work is distinctly seen during operation; black or white or silvered ground, without any deceptive glitter, and exactly as it is to be seen in the print. Clean the copper plate, and rub it with a clean rag and a little cyanide of silver. Remove the superfluous cyanide with a clean rag, and the plate will be properly silvered. If the cyanide is too thick, add a little spirits of wine. If it is wished to make the silver of a dead white, slightly roughen the surface of the copper before silvering with fine emery paper, rubbed from right to left, or from left to right, of the way it is intended to work the plate. Use a white ground, made by dissolving white wax in ether—a saturated solution. Let it settle a few days; the clear part only is required, the milky portion at the bottom, being undissolved particles, are probably insoluble and useless. To apply this ground, hold the plate underneath with a pneumatic holder; pour the solution on the silvered side; move the plate gently but firmly from side to side so that the solution may run to and fro; then pour all the superfluous ground back into the bottle. In finishing, move the plate more rapidly. Let the ground dry for 3 days. Apply a second coat in the same manner, and let it dry for 4 days in a quiet room, where it will not catch any dust. If the plate is dried by the heat of a spirit lamp, the ground will be transparent, but not of the dead white colour which is desirable. Paint the back and edges of the plate with japan varnish to protect them in the bath, which must be composed as follows: 20 grm. chlorate of potash, 100 grm. pure hydrochloric acid, 880 grm. water; or the same proportion in English weights. Warm the water, dissolve the chlorate of potash in it, then add the acid. Sketch the subject with some pale but decided water colour, red or yellow for example, using the point of a small camel-hair brush. This will remain visible whilst the plate is being etched, which must be done whilst it is in the bath; the acid will, of course, attack the needle, but this action keeps the needles sharp, and they are not costly tools. The bath should be formed in an oblong square piece of light wood, about 1½ in. thick, and larger than the well, which must be a square hole, a little larger than the plate, and about an inch deep. Cover the board and well with about six coats of japan, which protects the wood from the action of the acid, and the dark colour makes the plate look whiter from the contrast. A thin piece of wood, stained black, must be used as a hand-rest. Before using a new bath or well, dissolve a small piece each of copper and of zinc in it with acid. Lay the plate in the desired position, and fix it by pressing small pieces of modelling wax at the corners against the plate and the board. Etch with an ordinary strong sewing needle inserted in a holder. It must be sharp enough to scratch well through the silver, otherwise the line will not blacken at once. The wax ground permits the lines to enlarge slowly; thus there is a constant gradation in thickness from the first to the last lines; as the time of exposure diminishes, this property must be carefully attended to. Thus, if the subject requires only about 2 hours' work in etching, this must be spread over 5 hours' exposure in the bath, which is the time necessary to produce the darkest lines; other work can be carried on simultaneously, but this process cannot be hurried. If, however, the subject is elaborate, and requires more etching than can be finished in 5 hours, select for the first sitting various parts over the whole plate; clean and reground the plate; at the second-sitting add work to that previously done, and so on until the plate is finished, so arranging the times as to work always at the same period of the operation on tones intended to be of the same depth. This process is acquired with a little practice. If necessary to efface, it may be done in the usual manner with scraper and charcoal; always re-silver before retouching, if retouching is required. For cleaning the plates, turpentine is usually employed, but shale-oil or petroleum is a better cleanser, and removes the japan varnish very rapidly, whereas turpentine dissolves it slowly.

Etching from Nature.—Etching is the only kind of engraving which can conveniently be done directly from nature. The choice of subjects is the most important point, as, although etching is admirably adapted for trees and vegetation in all its forms, and for picturesque buildings and animals, it is not so well suited for the representation of figures, or for other subjects which require delicate gradations of tones. For anything that can be expressed by lines, etching is very successful, but it is not easy of application to tones. In working from nature, the shading, in addition to giving the light and dark tints, should also be used to indicate the form and texture of the surface, the lines being drawn in a direction to indicate form as well as tint. Several plates, ready grounded, may be carried in a small grooved box to keep them apart; if only one plate is intended to be used, it can be carried between two light boards, but must not be allowed to touch them. This can be avoided by fixing small pieces of modelling wax at the corners of the plate. If intended to be etched on Hamerton's positive process, the drawing-board, with the well in it, must be taken, and the necessary hydrochloric acid and chlorate of potash in two stoppered bottles. These can be mixed with water when required. Dry point is frequently used in the finishing of etched plates. The dry point is an ordinary steel etching needle, sharpened in a peculiar manner with a sharp rounded cutting edge, and used without either etching-ground or acid bath. By using this tool on the bare copper, a burr is raised, which catches the ink, and in printing gives the desired effect of a line with a delicate gradation. The more perpendicular the needle is held the less burr there will be raised; by inclining the hand to the right the burr will be increased, if the pressure on the tool remains the same. Practice enables an etcher to regulate the pressure on the tool; but if the pressure used has raised too strong a burr, it can be partially or entirely removed by using a sharp scraper worked at right angles to the line. If it is desired to see the progress of the work, rub a mixture of tallow and lampblack over the plate; remove what is superfluous with a soft rag; the effect of the etching can then be fairly judged of. Dry point etching can now be made to give a large number of impressions, by having the plate protected with a coating of steel applied by galvanism. To efface faulty work, use sand-papers of several degrees of coarseness; the coarsest first, then the scraper; finally, rub over with willow charcoal and olive-oil. This leaves the plate fit to be etched upon; if, however, it should be hollowed out by this process, mark the spot on the back of the plate by means of callipers. Lay the face of the plate on a block of polished steel, and give it 2 or 3 blows on the back with a rounded hammer. The engravers' copper planers will do this work with more precision and skill than can easily be acquired by ordinary etchers. A passage that has been over-bitten may be easily reduced by being rubbed with willow charcoal and olive-oil, which merely reduces the copper without injuring the lines, except the very pale ones; these must be etched over again. It is better to have the plate over-bitten than not enough, as the former is more easily remedied than the latter.

Stippling is also executed on the etching ground by dots instead of lines made with the etching needle, which, according to the intensity of the shadow to be represented, are made thicker and closer. The work is then bit-in.

Miscellaneous Recipes and Processes.—*Etching Fluid* (good). 2 oz. verdigris, 2 oz. common salt, 2 oz. sal-ammoniac, ¼ oz. alum. All these to be in powder. Put them in 4 oz. strong vinegar with ½ lb. water. Bring to the boil for a minute to dissolve, then cool, and pour off the clear fluid.

(2) This is executed much in the same way as in the process on copper. The plate is bedded on common glaziers' putty, and a ground of black, or wax, is laid in the usual way, through which the needle scratches. It is then bitten-in. (3) Iron filings 1 dr., iodine 2 oz., put into ½ lb. water. When dissolved is ready for use.

Etching on Steel or Iron.—Take sulphate of copper, sulphate of alumina, and muriate of soda, of each 2 dr., and strong acetic acid 1½ oz., mixed together. First smear the part intended to be etched with yellow soap, and write with a quill pen without a *split.*

For Steel or Copper.—Mix 2 oz. alcohol with 8 oz. pyroligneous acid, then add 2 oz. nitric acid.

Etching on Cast Iron.—Use a solution of common salt and sulphate of copper for the biting-in.

Etching Fluid for Metals.—Mix together 8 oz. nitric acid and 1 oz. muriatic acid. Melted beeswax is used for the resist, where the acid is not required to act.

Etching Brass Name Plates.—The brass plate is of any desired thickness between 1/16 in. and ⅛ in., made quite level, and well polished on the side that the engraving is to be done. Warm the plate a little, so that by rubbing white-wax or beeswax, upon it, a good even coating is obtained. The desired design or lettering is then carefully scraped away leaving the brass quite clean in these parts, so that the acid may act upon it. A wall of wax is then made around the edge of the plate (or on the plate, around the lettering) and the dilute nitric acid is poured in. To get the lettering correctly spaced it may first be done on paper then transferred to the waxed plate by simply putting carbon paper between and going over the lines with a hard pencil or metal point.

Glass.—*Etching Fluid or Ink for Glass.* (1) 1 oz. fluoride of ammonia, 1 oz. hydrochloric acid, 1 oz. dry precipitated barium sulphate. Rub together in a mortar. When well mixed, put these in a pan made of gutta-percha or platinum and pour gradually on the mixture some fuming hydro-fluoric acid, stirring quickly with a thick gutta-percha rod or pestle until the impression left by the rod quickly disappears. The fluid is now ready for use, being a rapid etcher of glass, making a nice roughened surface. About 12 to 15 minutes is the time taken by the etching; longer than this does more harm than good, the sharpness of the outline probably being lost. It is important, for the successful making of this ink, that the barium sulphate be of good quality; it is essential. This fluid is injurious, if left in contact with the skin; great care must be used, not letting the fluid touch the hands, or if it touches, wash the parts immediately.

(2) Druggist bottles, bar-tumblers, signs, and glassware of every description, can be lettered in a beautiful style of art, by simply giving the article to be engraved, or etched, a thin coat of etching-ground, and the application of fluoric acid. Before doing so, the glass must be thoroughly cleaned and heated, so that it can hardly be held. The ground is then to be applied lightly over, and made smooth by dabbing it with a small ball of silk, filled with cotton. When dry and even, the lines may be traced on it by a sharp steel, cutting clear through the varnish to the glass. The varnish must be removed clean from each letter, otherwise it will be an imperfect job. When all is ready, pour on or apply the fluoric acid with a feather, filling each letter. Let it remain until it etches to the required depth, then wash off with water, and remove the varnish.

(3) *Fluoric Acid, to make for Etching Purposes.*—You can make your own fluoric (sometimes called hydrofluoric) acid, by getting the fluor or Derbyshire spar, pulverising it, and putting all of it into sulphuric acid, which the acid will cut or dissolve. Inasmuch as fluoric acid is destructive to glass, it cannot be kept in common bottles, but must be kept in lead or gutta-percha bottles.

(4) Glass is etched by hydrofluoric acid, or by hydrofluoric acid gas. The gaseous acid has the property of producing a surface which resembles ground glass in its appearance; the liquid acid produces clear etching. Etching glass, therefore consists of 2 distinct branches—1st, the production of a dull image on a clear surface (when the gas is used); 2nd, the production of a clear image on a surface previously ground or dulled by means of the liquid acid. 1st, the glass plate to be etched is cleaned, and gently warmed until hot enough to melt wax. The surface is then covered with an equable layer of white wax, by rubbing the wax over it. When cold, the design is cut out of the wax with a graver. A shallow leaden trough, about the size of the plate (but a trifle smaller) is obtained, into which is placed a small quantity of finely-powdered fluorspar. This must be weighed and then gently sifted over the bottom of the trough. To every 2 parts by weight of fluorspar add 3 of good oil of vitriol. Stir quickly with a wooden stick, and place on the hob or other warm place. Vapour will soon rise. Now remove the trough and cover over with the waxed and graved plate, wax side downwards. In a very short time the acid will have etched the bare portions of the glass. When sufficiently etched, remove the wax by melting. Conduct these operations under a chimney, to carry off the vapours, as they are very injurious. To prepare the liquid acid for clear etching, place 2 parts fluorspar and 3 of sulphuric acid in a leaden retort, the tube of which must dip into a leaden bottle half-filled with water. Apply heat to the retort as long as the water will absorb the fumes generated. If a ground glass be prepared with wax, as above, and a ledge of wax or putty be made round it, on pouring the liquid acid on the plate, clear lines on the dull ground will result; or a "flashed" coloured glass may, by the same means, be made to present a colourless picture on a coloured ground. The sheets of clear glass may themselves be dulled by exposing them, without previously waxing, to the fumes of the acid gas. N.B.—Hydrofluoric acid produces most painful and malignant ulcers.

(5) The etching of photographs on glass is a process little practised by photographers and yet some pretty

applications may be made by ornamenting globes, vases, and drinking-glasses in this manner. It is true some glass is better adapted for the purpose than others, and that which contains a good deal of lead is said to be the most suitable. Any photographic film is sufficiently thick for protecting the glass where the etching liquid is not to act, and designs or pictures may therefore easily be formed capable of resisting the action of hydrofluoric acid, which dissolves the rest of the surface. Glass which is faced with a surface of colour or opal may be worked with great ease, and the acid coming in contact with the unprotected surface dissolves away the facing, and leaves either a design in transparent glass, or one in colour, according as a negative or positive has been made use of to produce the mask upon the glass. A dilute acid is employed for etching in preference to a strong one, and the time that is required to dissolve away the surface depends in great measure upon the character of the glass itself. A carbon film will suit very well as a mask, and in this case it is well to apply the moist solarised tissue to the glass surface, and develop the image upon the glass. The image, under these circumstances, holds very tenaciously to the glass surface (which has not been waxed, it must be remembered), and, when dry, the glass object is transferred to the etching bath, where, if it happens to be a lamp globe, it is kept slowly revolving. The etching bath is made of guttapercha, or wood protected with sheet lead, and the object remains herein until the etching has proceeded far enough. When this is the case, the glass is withdrawn, washed, and then the carbon or other images removed in any ready manner that may suggest itself. In the case of designs or lithographs which it is desired to etch upon glass, a special ink is employed, which is applied to the surfaces to be protected from the action of the acid. This ink is a thick solution of asphalte in turpentine, thickened by means of beeswax and rosin. In this case, as also in the case of photographs to be reproduced in ground glass or colours, it is necessary that the glass surface to be etched should, in the first place, be of ground glass, or faced with coloured glass, blue, red, green, violet, etc., according to desire. The lithographic ink or photographic film forming the design then protects the coloured or ground glass, and the rest of the surface being washed away until the transparent glass underneath comes into view, there results a coloured or ground-glass design upon transparent glass.

(6) The process here described consists in corroding glass by violently projecting sand upon its surface by means of a current of air or steam. The apparatus used is very simple, and is shown in Fig. 108. Well-dried sand, contained in the cylindrical vessel *a*, is allowed to flow in a con-

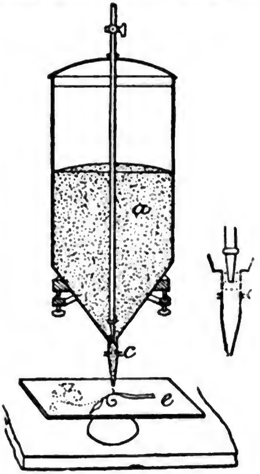


FIG. 108.

tinuous manner through the tube *c*, whose length and inclination can be altered at will, so as to regulate the fall of the sand. The tube conveying the current of air or steam terminates just above this spout, in a nozzle containing a series of fine holes. The sand, urged on by the jet, is thrown violently against the glass plate *e*, or other body placed within its range, and thus exerts a corroding action. By varying the quantity of the sand, the volume and velocity of the current, as well as the diameter of the jet, more or less rapid effects are produced.

In engraving on glass very little pressure is needed, the current from the bellows of an enameller's lamp being quite sufficient. In this way the divisions on graduated tubes, the labels on bottles, etc., can easily be engraved in laboratories with but little trouble.

The portions of the glass which are to remain clear are covered with paper, or with an elastic varnish, these substances being sufficiently exempt from the corroding action of the sand.

(7) A. Müller Jacobs has lately described a photomechanical process for etching on glass which possesses several novel features. The inventor has previously shown that certain resinate colours are sensitive to light, and, after exposure to light, the dye stuff becomes soluble in alcohol or other solvent. The sensitive resinate is made as follows :—

Colophony . .	100 grm.
Caustic soda . .	10 ,,
Crystals sodium carbonate . .	33 ,,
Water	1000 c.c.

The mixture is boiled for 2 hours with 1000 c.c. water, and is then mixed with 500 c.c. of a hot solution of 7·5 grm. methyl violet 3 B (methyl green, chrysoldine, magenta, etc.); 60 grm. magnesium sulphate are now gradually stirred into the solution, and the precipitated colour is washed and dried at 60° C. The sensitive film is prepared from these resinate colours by dissolving a mixture of 20 grm. resinate violet, 8 grm. resinate green, 8 grm. of the chrysoldine, and 4 grm. of the magenta in 130 c.c. pure benzene and 70 c.c. chloroform. This solution is then mixed with 120 c.c. of a caoutchouc solution (50 grm. caoutchouc, digested with 4000 grm. carbon bisulphide, heated on a water bath until half the bisulphide has distilled off, then benzene added to make the total weight 3333 grm.). After standing for a few days the solution is filtered through cotton wool, and kept in the dark for use. The plates can be either of metal or glass, and are coated with this mixture, dried, and exposed to light under the negative which is to be reproduced. The time of exposure varies from ¼ to 3 hours, depending on the intensity of light and the relative amounts of green and red dyestuffs in the resinate colour used. The exposed plate is kept in a cool, dark place until ready for developing. This process consists in immersing the plate in a solution of 1 part benzene and 3 parts turpentine. After the solution of the soluble colours, the plate is washed in petroleum spirit, and made ready for the etching process. For matt etching on glass the author recommends fuming hydrofluoric acid containing 10 per cent. of water. (' Industries.')

(8) Comparatively cheap etching solutions can be prepared, which are equal in effect to the expensive fluorine salts.

(*a*) Two solutions are first prepared, (*a*) consisting of 10 grm. soda in 20 grm. warm water, (*b*) consisting of 10 grm. potassium carbonate in 20 grm. warm water. Solutions (*a*) and (*b*) are now mixed, and to the mixture is added 20 grm. concentrated hydrofluoric acid, and afterwards a solution (*c*), consisting of 10 grm. potassium sulphate in 10 grm. water, is added.

(*b*) Mix 4 c.c. water, 1⅓ grm. potassium carbonate, 0·5 c.c. dilute hydrofluoric acid, 0·5 c.c. hydrochloric acid, and 0·5 c.c. potassium sulphate. This mixture is treated with hydrofluoric acid and carbonate of potassium, until it produces the required degree of opacity on being tried upon a piece of glass.

The addition of a small quantity of hydrofluoric acid to solution (*a*) brings about a fine granulated appearance on the surface. (Lainer.)

(9) A still simpler process than either of these has been invented by Kampmann. In preparing an opaque etching fluid Kampmann uses a wooden vessel, the iron fittings of which are protected from the corrosive action of the acid fumes by a layer of asphaltous material. This vessel is filled to about ⅕ its contents with strong hydrofluoric acid, which is then partially neutralised by cautiously and gradually adding some crystals of soda; more soda is added, and the mixture is stirred with a small wooden rod. The point at which the neutralisation of the acid should cease is indicated by the mixture frothing and becoming sufficiently viscid to adhere to the stirring rod. It is, perhaps, scarcely necessary to say that the acid fumes are highly injurious, and that this process should be carried on in the open air, in order to allow the vapour to pass rapidly away. The most hygienic and satisfactory process of all would be to carry on the operation in a "draught cupboard."

The contents of this wooden vessel now consist of sodium fluoride and the unneutralised hydrofluoric acid. This mixture is transferred to a wooden tub and diluted with 5–10 times its volume of water, according to the degree of dilution desired. It is objectionable to use the mixture in a too highly concentrated condition, for then the etched surface of the glass is irregular, coarse-grained, and apparently strewn with tiny crystals; if, on the other hand, the dilution is too extreme, the etched surfaces will be transparent instead of opaque. Either of these two conditions of the etching fluid can easily be remedied, for if it be too strong, water must be added, and if too weak, a small quantity of hydrofluoric acid partially neutralised with soda. A good recipe for preparing a small quantity of this etching fluid is the following: 240 c.c. commercial hydrofluoric acid, 600 grm. powdered crystallised soda, 100 c.c. water.

These etching fluids are best used by taking the following precautions. The glass is first thoroughly cleansed from all impurities, and is then provided with a rim of wax composed of the following ingredients: Beeswax, tallow, colophony, and powdered asphalte, kneaded together. The rim prevents the acid from spreading over those parts of the surface which it is not desired to etch. The glass is then etched for a few minutes with an ordinary etching solution (H.F.—1 : 10) which is then poured off, the surface being afterwards washed with water, and wiped as dry as possible with a piece of sponge. The surface is then ready for the opaque etching fluid, which is poured on till it forms a thick layer. The operation is allowed to progress for one hour, when the liquid is poured away, and the surface washed with water. Water is further allowed to stand on the glass until a thin film of silicate is observed to form; the film is then brushed off, the surface is finally cleansed with water, and the wax is removed.

By varying the action of this opaque etching fluid or paste, various degrees of opacity may be produced, and if the opacity be greater than that which is desired, the surface can be cleared to any extent by using the etching solution of hydrofluoric acid.

(10) The ordinary embossing one sees on shop-doors etc., is almost always done on plate-glass. A drawing on paper is first made; then by placing a piece of "transfer paper" (this can be bought at any artist's colour shop) under it and going over the design again, we obtain a reversed drawing on the other side of the paper. This is placed under the glass to work by. Those parts which are not to be acted on by the acid (hydrofluoric) are "protected" by a coating of Brunswick black, using a camel-hair brush. In a few hours or the next day a ridge of

tallow is made around the design about ¾ in. high; the glass is placed perfectly level, and the acid is poured on to the depth of ⅛ to ¼ in. When etched deep enough (a trial is made on a small piece of glass previously, as the time varies with the strength of the acid), in about ten minutes, pour off at one corner, wash with water, remove the black with turpentine, and clean well. The parts not acted on by the acid can now be ground with a small square of plate-glass and emery (medium). If the acid is too strong, it will not give sufficient time to pour on steadily. If it is too weak, it will require more than ten minutes. Good acid direct from the makers will take one-half water at least. The acid and water may be mixed in an ordinary clay pipkin, with handle such as used by gilders; but first melt some beeswax in it, and turn it about so as to give it a perfect coating, or the acid will eat its way through in a very short time.

Some very pretty effects are produced by what is known as "white" or "frosting" acid, used in conjunction with the ordinary hydrofluoric acid. For instance, we get out a design of a stork standing in the water among some rushes and water-lilies. The sky, water-lilies, and rushes may be frosted with the white acid, likewise some short horizontal lines on the water The stork and the water may be done with the ordinary hydrofluoric, and will be semi-transparent. The outlines of all the objects must have a burnished line around them—that is, the feathers of the stork, the petals of the flowers, etc. The burnished line is clear glass that has been protected by the Brunswick black.

The method is to protect all the burnished outlines and all the parts intended to be frosted, then treat with hydrofluoric acid in the way previously described, then clean all off nicely, and protect all the outlines again and all the parts acted on by the acid, and then pour on the white acid; the white acid must not be diluted.

White acid is prepared by adding ammonia to strong hydrofluoric acid, together with a preparation of barium. The reason amateurs do not succeed in making it is, they cannot, as a rule, procure the fluoric acid strong enough.

White acid is the same material that is sold under the name of "diamond writing-ink" for writing on glass with an ordinary pen.

(11) *Cosmos* recommends the following for marking designs or inscriptions on glass bottles, etc.: Dissolve about ·72 oz. fluoride of soda with ·14 oz. sulphate of potash in ½ pint of water. Make another solution of ·28 oz. chloride of zinc and 1·30 oz. hydrochloric acid in an equal quantity of water. Mix the solutions, and apply to the glass vessel with a pin or brush. At the end of half an hour the design should be sufficiently etched.

(12) Another process, devised by Meth and Kreitner, of Berlin, is given in 'Invention' as follows: A mixture consisting of ammonium fluoride, common salt, and carbonate of soda is prepared, and then placed in a guttapercha bottle containing fuming hydrofluoric acid and concentrated sulphuric acid. In a separate vessel which is made of lead, potassium fluoride is mixed with hydrochloric acid, and a little of this solution is added to the former, along with a small quantity of sodium silicate and ammonia. Some of the solution is dropped upon a rubber pad, and by means of a suitable rubber stamp, bearing the design which is to be reproduced, is transferred to the glass vessel that is to be etched.

* * *

EVAPORATING.

(*See also* DISTILLING, DRYING, PERFUMES, PRESERVING, SUGAR, ETC.)

EVAPORATION is resorted to for 2 distinct purposes: (*a*) for the sake of the material from which the vapour is liberated, (*b*) for the sake of the vapour itself. The former class only is dealt with here, the latter being chiefly represented by DISTILLING (*see* VOL. I.).

Evaporation is essentially a surface operation, hence a leading principle is the exposure of a maximum surface. Another point to be considered is facility for the escape of the vapour generated, preventing its impeding the progress of the operation by pressing on the surface. A third consideration is the avoidance of condensation of the liberated vapour by contact with a cold surrounding medium, either solid or vaporous, so that it can fall back into the mass undergoing evaporation.

The ordinary basis of calculation for evaporating surface is that 10 sq. ft. of heated surface will evaporate 1 lb. of water per minute; and that a thin copper tube exposing 10 ft. of surface will condense about 3 lb. of steam per minute, with a difference of temperature of about 90° F., in other words, 30° F. per lb. Hence, steam employed for evaporating purposes should be at $212° + 30° = 242°$ F.

Evaporation is the only normal mode of vaporisation of liquids. Gernez has also shown that with all liquid evaporated at temperatures above the boiling point, there is a rate of evaporation which remains constant at every temperature, whatever may be the surrounding temperature, and that the rate of evaporation is sensibly independent of the nature of the medium into which the vapour is disengaged. The duration of evaporation of a column of liquid of determined height, measured when disengaged freely into the atmosphere, and when ignited at the extremity of a tube, proved this; a column of carbon bisulphide, 50 millimetres in height, heated to 90°, discharged itself into the atmosphere in 2 minutes 26 seconds, and in 2 minutes 27 seconds when the vapour was ignited at the end of a tube. In the same tube, containing the same quantity of liquid heated to 100°, the period of evaporation was 1 minute 46 seconds, whether the vapour was ignited or not. The rapidity of evaporation is inversely as the diameter of the tubes in which the evaporation is conducted, as the following numbers show:—

Diameters in millimetres.	15	5	3	2	1	0·35	0·2
Rate of evaporation.	1	2·2	2·7	3·6	10	21·90	30·0

In dealing with means of conducting artificial evaporation from a technical point of view, it will be convenient to adopt a classification based on the nature of the article treated and the conditions demanded by it. The chief kinds of liquids subjected to evaporation are: (1) Saline solutions, for the purpose of recovering their solid contents in crystalline form; (2) syrups, necessitating precautions against organic changes; and (3) acids, with a view of rendering them more highly concentrated.

Saline Solutions.—Sea water may be considered as a dilute saline solution, and its treatment for the recovery of common salt (sodium chloride) affords an example of the utilisation of natural heat (the sun's rays) for evaporation on a commercial scale.

The works in which the sea-salt industry is carried on consist of several series of basins communicating with one another, and possessing extensive evaporating surfaces. Through these, the sea-water is led until arriving in the last, which are very shallow; the already concentrated salt water is allowed to stand till most of the salt has crystallised out. The mother-liquor or "bittern" is drawn off, and the salt is collected and drained to dryness.

The first of the series of basins is

usually a large shallow pond, into which the sea-water is admitted, and where it is allowed to settle, and is stored for use. Sometimes two such large basins are employed, one for settling, the other for storage. Hence the water is carried through a series of other basins, each set in its turn being smaller and shallower. In the last, the salt principally deposits; it is then collected, drained, and stacked for sale.

These works are called by various names, according to the countries in which they are situate. In England they were known as "salt-marshes," "salterns," "salt-gardens" and by other local names. In France they are called *marais salants* or *salins*; in Portugal, *marinhas*; in Germany, *Meersalinen* or *Salzgärten*.

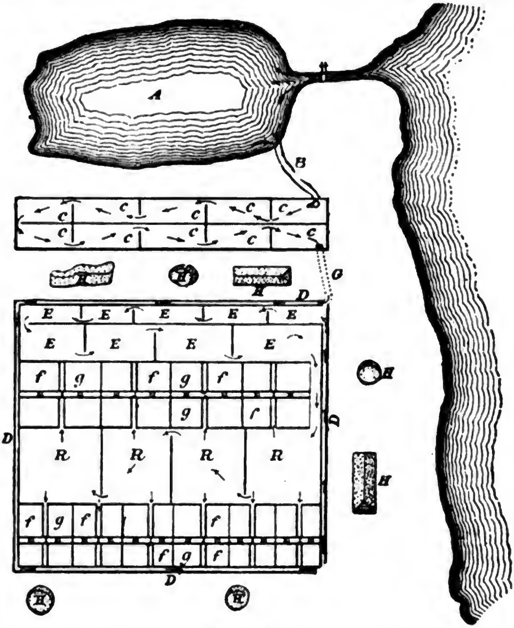


FIG. 109.

Fig. 109 shows a *marais salant* in use on the Atlantic coast of France. The spot chosen is generally some little bay or creek protected from the direct action of the waves; from this is led a small canal, through which at spring tides the sea-water can be conducted into the large reservoir A, the *jas* or *vasière* ("settler"), where the water is allowed to clarify. This reservoir is usually placed higher than the rest of the *marais salant*, so that the water can be run off at pleasure into the first set of basins or *couches* c, without pumping. The *jas* may be of any moderate dimensions, and often covers 2½ acres, the depth varying from a yard to a fathom. The water, having become thoroughly clarified in the *jas*, is allowed to run by the underground channel B, fitted with a suitable sluice, to the *couches* which are frequently about 23–24 ft. long, 12 ft. wide, and 1–1½ ft. deep, arranged in sets of 8 or 10 in a double row, as shown, separated by low walls or dams, but communicating with each other in such a manner that the water entering from A by the sluice B can circulate slowly through them, as shown by the lines and arrows, and be drawn off by the sluice G. In fine weather, the water has already undergone some degree of concentration by the time it has settled in the *jas* A, and as it passes in an almost insensible current through the *couches*, it continues to evaporate. It is led by the sluice G into a canal D, which nearly encircles the *marais salant*, and serves to conduct the water on to the *tables* E, arranged similarly to the *couches*; over these, it flows as before in an almost insensible current into other basins R, called *adernes* or *muants*, whence it is fed as required by small channels cut in the soil into the *œillets f g*, small basins where the salt crystallises.

On the shores of the Mediterranean about Cette, Marseilles, and the Étang de Berre, immense quantities of salt are produced by a somewhat similar arrangement. As, however, there are no tides in that sea, the arrangement with the separate reservoir A is not essential. A series of basins whose bottoms are levelled and plugged with clay, are made by sets in gradients (usually 3), so arranged with channels and sluices that the water can flow from basin to basin and from one set to another. The general principles involved are much the same as on the Atlantic coast. They differ, however, in the degree of the circulation of the water. In the western works, the water is allowed to almost stagnate as it were, no differences of level being maintained so as to promote its flow except in respect of the *jas* which is usually placed on a rather higher level. In the *salins du midi*, on the contrary, when the flowing water has reached its lowest gradient it is collected in large wells whence it is drawn up and thrown back by a pump or water-wheel to its former level, and again traverses a like set of gradients, to return once more to another set of wells. The first set are called "wells of green water," the second are called "salt water" wells.

Sometimes brine, whether derived from springs or otherwise, is not brought to the surface at a sufficient degree of concentration to be evaporated by artificial heat without too great a consumption of fuel. It then becomes necessary to concentrate the brine. The most economical mode of doing this is obviously spontaneous evaporation by exposure to the air; and in places by the seaside where high winds prevail, and where land may be of little value, large quantities of salt are economically produced, as already detailed by this means. But in other places, this arrangement would be inconvenient, and other means of exposing the liquid to evaporation on an extended surface are resorted to. Such is the so-called "graduation" system invented by Abith in the 16th century, and still practised in a few places on the Continent. A graduation-house (*Gradishaus*) is generally a huge shed, 300–400 yd. long, presenting one end to the prevailing wind, and open at both ends. The interior is filled with rows of fagots; the floor is a large flat reservoir or basin, and on the top, by means of pumps and other arrangements, the water is sprinkled profusely over the fagots, and in course of descending into the trough below trickles over the sticks, and exposes a large evaporating surface. By several repetitions of this process the liquor loses water, and a concentrated brine is the result. Fig. 110 represents the general construction of a graduation-house. A description of that at Schonebeck one of the largest and most important establishments of this kind will suffice, as the system is not required in England, and is becoming less used elsewhere. The building is 916 yd. long, and 11–14 yd. high. It is filled with a double tier of fagots, presenting a thickness of 5½–7½ yd. at its base, and 3¼–5½ yd. at the top, consequently offering an immense superficies for evaporation. The illustration shows the whole arrangement in profile, end on. *a* is the large reservoir for the salt water. It is excavated in the ground and widens out at the top to *c* to catch any drip the wind may carry away ; *d e* are merely stays to support the walls of the reservoir, and to sustain the building against the lateral pressure of the wind ; *f* is the wooden framework in which may be arranged 4 vertical walls or tiers of fagots. These fagots are made of white- or black-thorn, the branches of which are especially crooked and angular. The water is elevated by pumping to the reservoir *h* at the top, which is so arranged that the outflow can be altered according to the way of the wind. The water is allowed to descend through 2 pipes closed or opened at will by the valves *k* into the pipe *g* ; thence it rises through the pipes, and flows out by cocks into pans from the overflow of which it drips on to the fagots. Berthier calculates that the average evaporation in ordinary fine weather by this means at Moutiers, in Savoy, where cords are employed instead of fagots, the other general dispositions remaining the same, is 13⅙ gal. for every sq. ft. of cord surface in 24 hr. At Kissingen, the sheds are nearly 1¼ mile long by 25 ft. high. The water is raised 6 times in passing from one end to the other of the building, and by this, its strength is raised from 2½ to 17½ per cent. of salinity. Forbes has calcu-

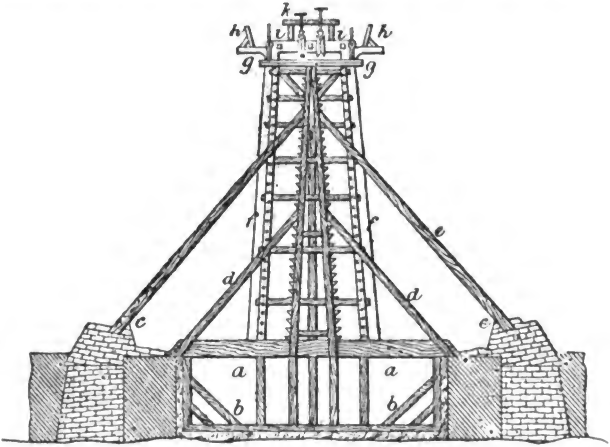


FIG. 110.

lated that here nearly 3 million cub. ft. of water are evaporated annually by this means. The first set of fagots are stained brown by ferric oxide which encrusts them, and they all have to be changed every 2 years or so on account of a deposit of calcium carbonate ("thornstone") which coats them. By whatever means the strong brine is obtained it needs evaporation to produce white salt.

Brine evaporating-pans are built of common boiler plate, ¼–⅜ in. thick, the plates being about 4 ft. long by 2 ft. wide, and well riveted together. The plates are usually of rather smaller dimensions in the part immediately over the fire than elsewhere on the bottom or floor of the pan, as by this means some of the tendency to warp and buckle is supposed to be avoided. In England, the usual dimensions for fine and extra-fine salt-pans are 30 ft. long by 22–25 ft. wide, and 1 ft. 9 in. deep. This gives an evaporating surface of 720–750 sq. ft. Butter-salt pans, are perhaps a trifle longer, say 35 ft. by 22–25 ft., and the same depth, with an evaporating surface of 770–875 sq. ft. Common and fishery pans range from 50 to 70 by 22–25 ft., and have the same depth, presenting an evaporating surface of 1100–1750 sq. ft.; some fishery salt-pans belonging to the British Salt Co. at Anderton are 90 ft. by 22, while at Stoke and Winsford, are fishery salt-pans ranging up to 130 ft. in length. Beyond 70 ft. in length, however, there really would not seem to be sufficient gain, at least with the quality of fuel used in Cheshire, to compensate the increased cost of construction and repairs. In France, the common and fishery salt-pans are about the same sizes as ours, only perhaps a trifle wider; and at Dombasle, near Nancy, where Botta has carried the manufacture to as great perfection as is attained in perhaps any works, the pans (*poêles*) are 72 ft. by 29½ ft. by 43½ in., with an evaporating surface of 2124 sq. ft.

The floor of a pan is usually made slightly arched upwards towards the centre, so that a new pan is rather deeper at its sides than in the middle; but they soon flatten out and warp in various directions under the influence of the firing. On the Continent, cast-iron pans have been in some cases adopted, and cast-iron plates substituted for the smaller wrought-iron ones universally employed in this country in the part of the pan just over the fires. Besides the advantage accruing from the less tendency to buckle and warp, the cast iron has a much higher conductive power than the wrought iron, and the advantage of cheapness. The plates are not made much thicker than the ordinary wrought plates, and are cast with exterior flanges all round their edges, by which they can be bolted together beneath the pan. They also have grooves cast in their edges, to receive asbestos cord or cement, by which, when screwed up, they can be made watertight. Were it not for fear of their greater fragility and some difficulties of adjustment, they would doubtless be employed in this country, thus avoiding leakages into the flues, and the consequent production of large stalactites of salt, technically termed "cats," an intolerable nuisance to the salt-maker. In Austria, such cast-iron pans are now in use, and their advantages will be manifest from the following comparative experiments made at Berchtesgaden under like conditions of firing, etc.:—

	Temperature attained in the pan.	Cost of maintenance.	Durability.
		£	years.
Sheet iron	64·4°F.	74·8	12
Cast iron	75·2°F.	34·4	21

It is also sometimes the practice abroad to make the pans with plates riveted on to T-iron bars running across the width of the entire pan, the central flange of the T-iron standing up between the edges of the plates, and these latter having the rivets countersunk into them. This seems somewhat to prevent the buckling.

Wooden pans have been and still are employed. One belonging to Thompson, of Northwich, is 4 ft. 6 in. deep, 12 ft. wide, and 75 ft. long, The 2 ends are of sheet iron, and a long sheet iron cylinder, closed at the 2 ends by steam-tight doors, runs from end to end. This cylinder is about 18 in. diam., and is supplied from above at about the middle of the pan by means of a lateral pipe with waste steam from an engine and boiler near. By this, the pan is kept at a temperature of about 90°–100°F. This pan is said to produce 45–50 tons of extra fishery salt every 6 weeks or so.

In Cheshire and Worcestershire, the fire-places, usually 4 in number, measure about 4–5 ft. from the door to the back, and are about 3½–4 ft. wide; from the bottom of the pan to the grate bars is usually about 3 ft. In the case of very long pans, this height may increase to 3 ft. 4–5 in. The grates are formed of square wrought-iron bars, it being found inconvenient in salt-works to employ the improved cast-iron "fish-bellied" bars. This is on account of the great liability to choking with clinkers, and caking of the ashes with the brine which drips from leaks over the fires fusing into clinker, and clogging the grate-bars. The blows necessary to detach these masses would seriously endanger cast-iron bars; but certainly the shape of the bars might well be improved, and rocking-bars, such as those employed in pyrites-kilns and elsewhere, might be more generally introduced with advantage. The firing is usually done in a stoke-hole with steps on each side leading up to the pathway around the pan.

In France, often 2 fires only are put under each pan. The general construction of a French salt-works is rather more regular than in those of this country, and the pans are usually placed side by side in sheds, while a common flue connects with the outlet-flue of each pan, and such arrangements are made that, when required, any one pan can be cut off by a damper. This common flue is made to pass beneath one or more long deep pans fed with cold brine, and from these the brine is fed, already more or less warmed, into the evaporating-pans. English pans are always set on brickwork, and their bottoms stand about on a level with the ground, overlapping their sustaining walls by some inches, and reposing on longitudinal flues. These latter are usually 4, corresponding in number with the fires, and run straight nearly the whole length of the pan, sometimes entering a chamber at the far end, and passing thence to a low chimney serving one or two pans; but sometimes they converge simply into one common flue, running the whole length of a row of pans, and having an exit to the main chimney. At times the flues do not continue the whole length of the pan, which is then supported here and there by pillars or bits of walls built in parallel lines. Sometimes no flues at all are employed, the pan being merely sustained by pillars and brickwork, sandstone, or cast iron. The whole space then beneath the pan constitutes one large flat flue, through which the heated gases find their way unencumbered. This plan is common in Worcestershire.

On the Continent, other dispositions of flues are often adopted. At Nancy, and pretty well throughout France, the flues from each fire (often only 2) run down to the end of the pan, returning towards the fire-end, and back again once more to the chimney or main flue, each flue thus forming 3 parallel lines. This plan has been tried in England, but is not now usually employed, the simpler form of straight flues leading from each fire right away to the chimney or common flue seeming generally to be preferred. Here in England also they usually have 2 "dead" flues, as they call them, one on each side beneath the pan, these being spaces like flues, but completely walled up at each end, so that no gases can enter them. The flues are usually 2–3 ft. deep, of a capacity in fact to admit a man or boy; and between the entrance of the flues and the fire-place, is built a wall of fire-brick, reaching to within 18 in. of the bottom of the pan. Over this "bridge," as it is called, the heated gases pass before entering the flue, and as the bricks of the bridge become red-hot, they tend to induce a more perfect combustion of the smoke before it enters the flues, where it would become too rapidly cooled by contact with the bottom of the pan, and soot would fall.

In Cheshire, and other places in England, the evaporating-pans are at times employed quite open and exposed to the sky, but nowadays they are mostly surrounded with sheds, these being furnished with ventilating openings in the roof, to facilitate the escape of steam. On the Continent, all except the fine and butter-salt pans are generally covered in with wooden trunks, flat on top with sides converging upwards, thus forming an elongated truncated cone about 5 ft. high over the pan. All along the lower parts of the sloping sides of this cover, and on both flanks of it, are frames fitted with shutters removable by hand. By removing one or other of these, the progress of the crystallisation may be watched. A shelf is sometimes made, running along the whole length of this cover of the pan, just above the shutters; and when the pan is drawn, the workmen fish out the salt with rakes and scoops, and let it drain a bit on the drainers alongside of the pan, corresponding to what our salt-makers call "hurdles," and then pitch it overhead on to this shelf, on which it is allowed to drain pretty completely, the drippings falling back into the pan; thence it is shovelled on to the flat top of the cover of the pan, which is set with tiles. On these tiles, which are kept hot by the steam within the trunk during the time the pan is at work, the salt becomes dried, and is then on a level with the bins (*magasins*) into which it is tipped from wagons for storage. From that end of the trunk farthest removed from the fires, rises a wooden chimney 10–15 ft. high, for carrying off the steam from each pan; it passes through the roof of the building in which the work is carried on. Sometimes fan-blowers are placed in this and the main chimney, to expedite the exit of the steam. It is asserted by many of the French salt-makers that notwithstanding the greater cost of covering in the pans in this manner, the lessened facility of egress for the steam, the inconvenience, and the somewhat larger amount of labour involved in drawing the pans, they are compensated by a considerable economy in the combustible employed, through the diminished loss of heat by radiation; certainly they obtain cleaner products than English salt-makers. At the Dombasle salt-works, one of the best-managed and best-organised in France, on the contrary, with 100 lb. of the small, poor coal from Saarbruck they only produce 160–170 lb. of common salt. This coal is, however, far inferior to the slack used in Cheshire and Worcestershire, and it is not employed for fine or butter-salt, being unable to maintain a pan in continued ebullition so small is its heating power. It is used on account of its low price, and its yielding a gentle diffused heat suitable for the work.

Both in England and abroad, attempts have been made to reduce the loss of heat, chiefly due to the scale in the pans and the soot of the flues, by heating by steam. Whatever economy there may be in this method, it has not made much progress among English salt-makers, though the system is a common one for other purposes in the salt districts. The steam-pipes get covered with scale, which is difficult to detach without injury to them, and they are rather in the way of drawing the pans.

So-called "machine-pans" are sometimes employed. They are usually worked in pairs, standing 20–30 ft. apart, with a small engine between, or a shafting running above several of them driven by an engine at one end; this shafting is geared by bevel-wheels to the stirrers, and is so arranged that any one or more of the pans can be thrown into or out of gear at will. The depth of the pans is 2 ft., and an opening is left in one side of each down to the bottom, this opening being closed with outside troughs riveted to the sides of the pans. The bottoms of these troughs go lower than the bottoms of the pans, so that any salt swept out of the openings falls into the troughs, and cannot return into the pans. The pans are fitted with conical covers of sheet iron, through the centre of which pass iron spindles, geared above to the pinions of the shafting by bevel-wheels, and resting on the bottoms of the pans, in which they are free to turn. These spindles are attached to their lower parts to arms or stirrers, carrying scrapers swinging loosely beneath them, and resting on the bottoms of the pans. The covers are fitted steam-tight upon the tops of the pans, and each is provided with one or more manholes, by which workmen can enter to clean the pans. Those parts of each cover corresponding to the parts left open in the sides of the pans are brought down so as to partially close the openings and come just low enough to dip into the brine about 2 in., when the pans are about ¾ filled, while the spindles passing through the covers turn in stuffing-boxes. Thus, when the pans are closed, they are steam-tight, and there is no exit for the steam unless by forcing the water out of the pans into the troughs, or passing off by the flues. Each pan is fired by 3 fires, and boiled as for fine salt, while the spindle carrying the arms and scrapers is made to rotate. The incrustation of the pans is thus for the most part avoided, while very fine salt is produced, and is swept by centrifugal motion into the troughs, whence it is continuously ladled with a scoop, drained on "hurdles," and sent to the stove or the butter-salt bins, as the case may require. The gases from the fire under the pans, and perhaps from the fire of the engine, are made to pass to the flues beneath the outer pans. Both the pans which are heated by the steam stand on short brick or iron columns without flues; the pans taking the waste gases are set upon winding flues such as already described as being in frequent use in France.

Sometimes an ordinary boiling-pan is mounted with a fishery-salt pan behind it, so that the flues from the former passing beneath the latter, this pan also becomes heated by the waste gases. The Cheshire Amalgamated Salt Co. have some interesting and peculiar composite pans, known as "clay" or "tank" pans, also working on this principle. Fig. 111 represents a ground plan of this arrangement, and Figs. 112, 113, 114, are transverse sections on the lines D E, F G, B C, respectively. The boiling-pan *a* is placed with its upper edge on a level with the ground or barely above it. It is of the usual depth of 1 ft. 9 in. and of the form shown. The fishery-salt pan *b* utilises the waste heat of the furnace-gases, after they leave the flues beneath *a*. There are 3 fire-places *f*, and 3 flues *e*, beneath *a*, together with 2 dead flues. Alongside of and parallel with the pans *a b*, is a pit or trench *c*, about 4 ft. deep, 10–12 ft. wide, and 30–40 ft. long. It is puddled with clay, and lined with bricks throughout the sides and bottom. The upper edges of this trench are about 4–5 in. below the level of the upper edge of the pan *a*. A parting wall of brickwork also divides this trench *c* longitudinally into 2 compartments of equal width. This wall, however, only goes to within about 10 ft. of the end of the trench farthest from the fires, and to within 2 ft. of that end which is in a line with them. The side of the pan *a* turned towards the trench is cut out at the end farthest from the fires, and a shallow channel of sheet iron, just as deep as the pan, connects it with the double trench, while the space *k*

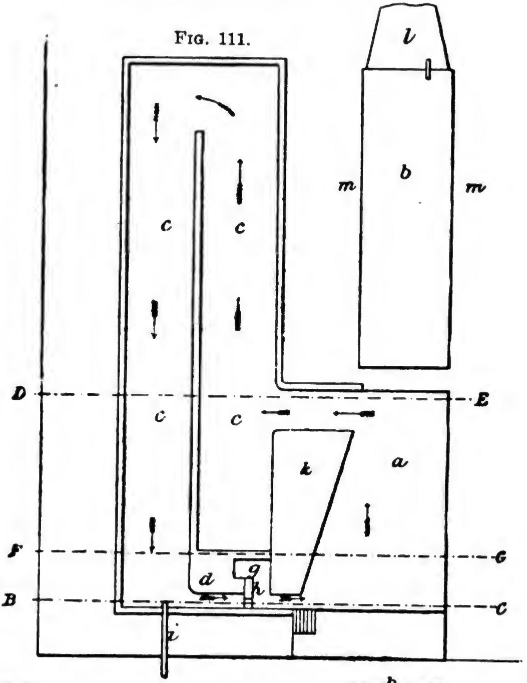


FIG. 111.

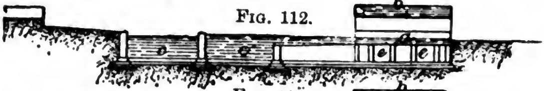


FIG. 112.

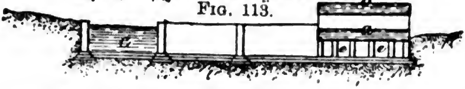


FIG. 113.

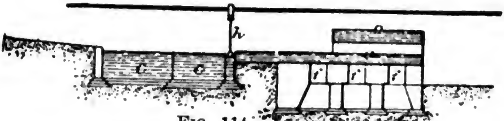
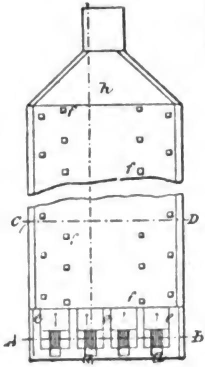


FIG. 114.

contained between *a* and the trench is filled up with a bed of masonry, the surface of which slopes gently from the upper edge of *a* towards *c*, so that the waste brine from any salt drawn on to it may drain into *c*. *k* is connected with *d* by a short wall, and a pump is placed at *h*, while another sheet-iron channel, only 2 ft. wide, but of the same depth as *a*, leads between the pump and the pan *a*. There is a small pit *g*, made of masonry, at the end of this channel; and at the end of the parting wall, at *d*, is a flat space just large enough for a man to stand upon to look after the pump when requisite. With this arrangement, if brine be poured in by the brine-pipe *i*, *c* will be filled, and if the influx of the brine be continued, *a* and *b* may be filled till *c* is nearly overflowing, and *a* becomes full to within 4–5 in. of its upper edge. If then the pump *h* be worked so as to lift the brine from *c* and cause it to fall into *g*, it will flow back into *a*, and, circulating through *a*, will pass again into *c*; thus a steady circulation of the brine may be maintained in the directions shown by the arrows on the ground plan, so long as the pump is kept going. If then the fires *f*, Fig. 114, be lit, the brine will be heated in *a*, and, circulating in the manner described, expose a large evaporating surface. The heat is so managed in these pans as to produce butter-salt in *a* and common salt in *c*; while at *g*, where the pump produces constant agitation, very fine salt is formed. Around the clay pan, the butter-salt pan, and the fishery-salt pan, are the usual paths for the circulation of the workmen, and the places for the so-called "hurdles" *m* upon which the salt is thrown to drain. The stoke-hole is below the level of the ground. The fishery-salt pan *b* may be mounted on columns of brickwork or cast-iron without separate flues, and the chimney at the end of this pan carries off the furnace-gases. These pans seem to produce very fine qualities of salt, particularly the common salt from the pit *c*. The yield is about the same (as regards weight of salt to weight of coal consumed) as with the ordinary pans, but the repairs are somewhat less, and certainly the qualities of salt produced are very fine. The chief drawback to them is a rather greater tendency of the pan *a* to become coated with scale, than in the case of the ordinary butter-salt pans.

Otto Pohl's arrangement consists of 2 superimposed pans, at one end of which the fires are placed; the heated gases, passing between them to the chimney at the other end, heat the upper pan from below in the ordinary way, while they sweep the surface of the brine in the lower pan, which thus constitutes the bed of this portion of the flue. Figs. 115 to 120 show this arrangement in ground plan, longitudinal and transverse sections, and in side and end elevations. Milner, of Marston, near Northwich, has a pan mounted on this same principle, which Pohl states to be an adaptation of the principle of the salting-down pans of the alkali-makers. His arrangement, however, differs from that of Pohl in that the upper pan is dispensed with, being replaced by an arch of brickwork. According to Pohl's system of construction, the lower pan is 5 ft. deep. It may be made of boiler-plate or of cast-iron, or for that matter, the bottom and lower parts of its sides might very well be made of elm or pitch-pine, with cast-iron ends and framing. Pohl tried brickwork for the construction of this lower pan, but abandoned it on account of leakage. In the pan figured, however, he has formed the bottom of tiles embedded in clay. Pillars of cast iron rising from the bottom *i* of this lower pan support the upper pan, which is of the ordinary make, and, demands no special description. The interval between the two need not, according to Pohl, be more than 3 in. In practice, however, 5–6 in. is not too much from the bottom of the upper pan to the surface of the brine in the lower one when completelfilled. The length of these pans is about 60 ft.; breadth of the upper one, about 20 ft., and of the lower one, 22 ft., the space between the two being filled all around with brickwork.

FIG. 115



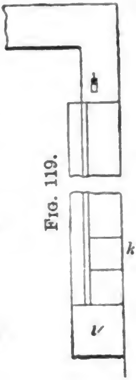


FIG. 119.

FIG. 220.

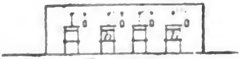
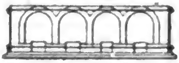


FIG. 118.



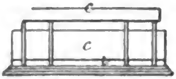


FIG. 117

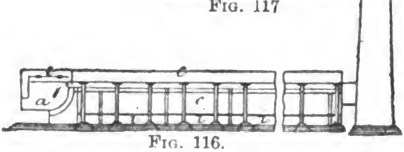


FIG. 116.

Milner has made the lower pan in his arrangement much wider than this, or rather it may be said a lip or opening running all along each side of the lower pan permits of the salt as it collects being drawn to the sides by rakes, and lifted out by perforated scoops as it accumulates. According to Pohl's arrangement, this might easily be managed by continuing the sides of his upper pan downwards for say 8–9 in., the pan being placed at such a height above the lower pan that these sides may dip 2–3 in. below the surface of the brine in the lower pan, and thus constitute a flue *f* 4–5 in. deep, through which the furnace gases might pass. The lower pan might then be made say 3 ft. wider than the upper one, so as to leave a trough on each side about 18 in. wide, through which the salt might be drawn. As it is, when the pan has to be drawn, which, of course, must be done as soon as it becomes full of salt, the fires have to be let out, the brine run off, and the salt drawn by the door or manhole *k*.

The furnaces in Otto Pohl's arrangement are 4 in number; they are made about 4 ft. wide internally, and 4½ ft. or even up to 6½ ft. between the top of the arch and the grate-bars; a distance of 3 ft. or so is also left at the back between the end of the grate and the lower pan, the angle being filled up with a curve of masonry as shown at *e*. This form of construction is intended to allow space for more perfect combustion, before the heated gases enter between the pans, where they tend to become rapidly cooled, with proportionate liability to deposit soot. Fig. 120 shows the front elevation and the arrangement of the sliding doors *b*. Pohl at first carried his upper pan right over the fires. He now stops short behind them, covering them in with arches of massive brickwork, so as to avoid as far as may be loss of heat by conduction in this quarter. He also proposed to make a sort of short circuitous flue, through which the products of combustion might be made to pass on their road to the space between the pans, by building 3 arches over the fires, constructed so as to reach alternately to the back and to the front of the fire-place, like the shelves of pyrites-dust kilns. These arches becoming strongly heated would aid in promoting the combustion of the smoke, while they served to catch the dust and ashes carried over from the fires. This plan, however, he appears to have abandoned. A further provision was made for getting rid of soot by keeping the lower pan always filled to the brim, making the end of it farthest removed from the fires a trifle lower than the fire end and sides, and keeping it full to the brim at that end. Much of the soot, falling on the surface of the brine in light flocks, would float thereon, and be carried off over the end of the pan by the draught towards the chimney.

Between that end of the pan and the entrance to the chimey is a soot-box or closet *n*, with a door for cleaning it out. Notwithstanding all these precautions, large quantities of soot are liable to become condensed, either upon the bottom of the upper pan, or between the 2 pans, and, falling on the surface of the brine, get carried down and mixed with the salt, rendering it black and totally unfit for food. This quality of salt, however, has been found specially suitable for the Hargreaves' salt-cake manufacture so that the small quantities now produced find a ready enough sale, as the salt does not signify. The method shows an important economy of coal, and, according to Pohl, gives 3 tons of butter-salt with the same amount of fuel and labour as is requisite for producing 2 tons by the old methods. The use of gas from a Dowson gas producer would obviate the soot completely, while it is probably preferable (according to Milner's plan) to do away altogether with the upper pan, employing merely a brick or tile covering as a reverberatory and radiating surface to throw the heat down into the lower pan, and so get rid of leakages, salt cats, and much cobbling and repairs involved in working by bottom heat. According to some experiments by Pohl, while the temperature of the upper pan remained suitable for making common salt, or ordinary fishery salt, that of the surface of the brine in the lower pan was maintained at full boiling, and the produce, so far as grain was concerned, was very fine butter-salt, while no scale worth mentioning forms in the lower pan. He gives as a result of 16 days' boiling with brine containing 25·27 per cent. salt, for 57 tons of slack (from Little Houlton Colliery, Lancashire) burnt—82 tons of fine butter-salt, and 49 of common salt; while on the old system, the 82 tons butter-salt would have taken 54 tons 13 cwt., and the 49 tons of common salt, 26½ tons, or a total of 81 tons 3 cwt., showing an economy of 24 tons 3 cwt. Instead of the gases escaping into the chimney at a temperature of 600° F. (315°C.) as during the manufacture of salt with the ordinary common salt pans, or at a temperature of 800°–1000°F. (425°–538°C.), as when making butter-salt, they never rose, even with the strongest firing, above 288°F. (142°C.).

Pohl states that in a subsequent trial, after lifting the top pan at the end nearest the fires to a height of 6 in. and lowering the other end to within 3 in. of the surface of the brine in the bottom pan, he obtained, as an average result of a series of boilings, 3 tons of salt for 1 ton of slack, the gases passing off at a still lower temperature; while in the top pan 200°–208°F. (93°–98°C.) was the temperature attained in front, 180°F. (82°C.) in the middle, and 160°F. (71°C.) at the far end.

Soda Salts.—The various descriptions of soda pan and setting are shown in Figs. 121 to 126. The apparatus is usually termed a "boat" pan from its shape. It will be noticed that the pan is so set in brickwork that the fire only plays upon the sides about half-way up. Consequently, the soda salt, as it crystallises out, accumulates at the bottom of the pan and is then "fished" out up the sloping sides, being protected by the solid brickwork from being burned. An ingenious form of pan has been occasionally tried. It consists of 2 compartments, the one heated and the other kept cool, connected by a large tube. The liquors are kept in constant circulation between the 2 compartments, crystallising out in the cold one, and the mother-liquors being pumped back. It has also been proposed to fish salts of different value from the boiling-down pan at different stages of concentration, leaving the mother liquors to be finally worked up into a caustic ash. Upon the whole, the method of boiling down by the waste heat passing over the surface of the liquors is the most economical, proper care in the subsequent finishing process rendering it perfectly easy to produce a satisfactory carbonate.

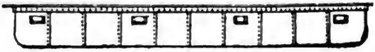


FIG 121.

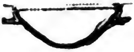


FIG 122.

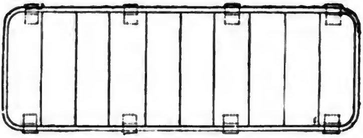


FIG 123

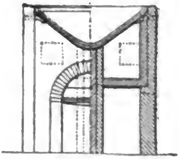


Fig. 124.

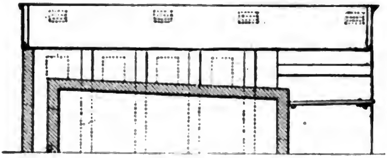


FIG. 125.

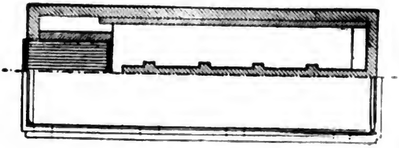


FIG. 126.

Lime Acetate Liquor.—Two forms of evaporating-pan for lime acetate liquors are shown in Figs. 127 and 128. The former is the better, as the salt raked up on the shelving end of the pan shown in Fig. 128 is apt to burn, and the drainings are returned to the pan cold. In some works, the acetate liquor, instead of being allowed to crystallise out in the manner described, is boiled down to dryness in a pot of the form shown in Fig. 129. In this way only an inferior article is obtained but by evaporating to dryness in a shallow sheet-iron pan, similar to that shown in Fig. 127, a fine product may result.

Chlorate of Potash.—Every manufacturer of potash chlorate is aware that his boiling-down pans are acted upon by the liquors, even when they are free from chlorine or hypochlorite. The clear liquid becomes turbid during the evaporation, and in the case of iron pans deposits a red muddy precipitate. In the case of lead, the formation of a mud is not so conspicuous; evidently the lead oxide originally formed decomposes with potassium chloride into caustic potash and lead chloride, at least partially. Usually it is assumed that lead is less acted upon than iron, but the latter is often preferred as being more durable. It seems to be an open question whether cast iron or wrought iron is more suitable for such boiling-down pans; the latter are cheaper for large sizes and more easily repaired than cast-iron pans, but are more quickly acted upon by the liquors.

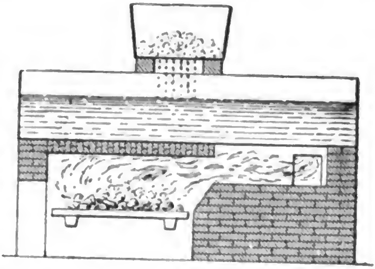


FIG. 127.

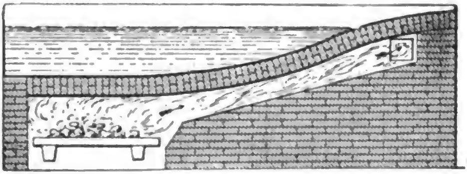


FIG. 128

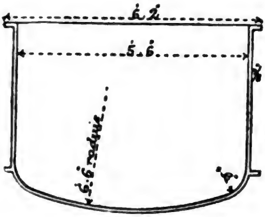


FIG. 129.

Some experiments made by Dr. Lunge induced him to arrive at the following conclusions:—

1. All metals employed are acted upon by the boiling liquors treated therein, more so by concentrated than by dilute solutions of potassium chlorate, and most of all by the mixed solution of calcium chlorate and chloride formed in manufacturing.

2. The weight of metal dissolved is always smallest in the case of cast iron, by far the greatest in the case of lead, wrought iron holding a middle place

but being not much worse than cast iron. If we consider that the calculations from the chloride formed are made from pure iron, but that cast iron only contains 90-93 per cent. of such, the difference between cast and wrought iron is still reduced.

3. The weight of chlorate destroyed does not differ very materially whether cast iron or lead is employed.

4. Since in any case the quantity of chlorate destroyed is not essentially less in the case of lead pans than in that of iron pans, but the loss of metal dissolved (as well as the cost of firing and repairs) is much greater with lead than with iron, boiling-down pans made of iron are preferable to leaden ones. According to the practically most important series of experiments, there is no essential difference in respect of action between cast and wrought iron.

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EXPLOSIVES AND BLASTING COMPOUNDS.

Gunpowder. — The component parts of gunpowder are saltpetre, sulphur and charcoal. The proportions of these ingredients vary a little, but as will be seen from the table given further on, the variation is but slight.

Saltpetre.—Crude saltpetre cannot be used for making gunpowder. The crystalline flour, quite free from chloride, is the best for the purpose. The washing process is carried so far that nitrate of silver produces no precipitate in the purified saltpetre. The general rule is to use the saltpetre whilst slightly damp, allowing for the proportion of moisture when mixing with the other ingredients. This saves the processes of drying and grinding the saltpetre before mixing with the sulphur and charcoal.

Sulphur.—Refined sulphur in rolls is used. This must be reduced to an impalpable powder, which is usually effected by placing the sulphur in hollow wooden drums having projections or brackets inside. A number of small brass balls are put into the drum with the sulphur, and the drum is made to revolve for six hours, when the action of the balls and projections reduces the sulphur to very fine powder, which is then extracted through wire gauze. Any small particles of sand, or unequally pulverised sulphur, are then separated by a bolting machine.

Charcoal.—The quality of the charcoal depends greatly upon the material from which it is obtained, and the manner in which it is prepared. The soft, woody parts of plants, which yield a friable, porous charcoal, leaving very little ash, are preferred. Black alder spindle tree, poplar, chestnut, vinestalks and willow, are most esteemed. Hemp-stalks, fibres of flax, and old linen also yield a very good charcoal. Remove the bark, leaves, and smaller branches, selecting branches 1 to 2 inches in thickness. These are cut into lengths of 5 or 6 feet, and tied in bundles, weighing about 30 lb. The wood will not be injured by exposure to the rain, as that tends to remove extractive matter. The carbonisation is effected either in pits, or in cast-iron cylinders. The yield of charcoal is 18 to 20 per cent., when prepared in pits; and 34 to 40 per cent. when prepared in cast-iron cylinders. The process of manufacture is similar to that adopted for ordinary charcoal, the pits or cylinders, however, replacing the ordinary kiln. If the charcoal is intended for sporting powder, it may be withdrawn whilst of a brown colour, when it is called "red charcoal." This would make a powder too explosive for war purposes. The latter is prepared from the black or distilled charcoal, which is more completely calcined, and is used by all English makers. The best quality has a bluish black colour, is light, firm, and slightly flexible, and should be used immediately it is made, as it rapidly deteriorates by keeping. Charcoal that has been too highly burned for war powder is used in the manufacture of blasting powder, as that need not be so inflammable.

Pulverising.—The required quantities of sulphur and charcoal are thoroughly pulverised, and intimately mixed, by being rolled for about four hours in a cast-iron drum, with numerous small brass balls, at a speed of about 28 revolutions a minute. When the mixture is complete, the powdered sulphur and charcoal are removed from the drum, and a proportionate quantity of saltpetre is added. Great care must be used in weighing out the various ingredients, according to the quality of the powder required, as upon that, and the complete mixing of the materials, the success of the manufacture depends.

Mixing.—The powder is put in a mixing machine, which is a leather drum, in which are placed numerous small bronze balls. The machine revolves at 25 to 30 revolutions a minute, and in about 4 hours' time the mixing is complete.

Granulating.—The powder having been damped and pressed into cakes, must then be crushed to the required size of grain. It is first roughly broken into lumps by small mallets; it is then fed into the granulating machine, which is caused to revolve for 35 or 40 minutes, at about 10 revolutions a minute. A small stream of water enters the granulator; the movement of the machine rolling the damp grains constantly among the dry meal-powder causes the latter to adhere to their surface, and each grain is thus increased by concentric layers. When the small meal-powder is all absorbed by the action of the granulator, the material is placed in a barrel ready for equalisation.

Equalising.— The grains as they come from the granulator are of various sizes; they are therefore sifted over two leather or parchment sieves, one of which is pierced to separate the grains which are too large, whilst the other allows all the dust to pass through, retaining only the grains which are of the desired size. The small refuse powder which has passed through the sieve is again placed in the granulator, and acted upon as before described.

Glazing.—The powder is placed in a cask or barrel, which revolves on its axis at about 40 revolutions a minute; by the friction of the grains against each other they become round, smooth, and polished, in which state the powder will bear the shaking and friction of carriage without injury, and is less likely to absorb moisture than when in rough and angular grains.

Drying.—The powder must not be too rapidly dried, a temperature commencing at about 66° F., and gradually increased to 130° or 140° F., is a safe one; the operation requires 3 to 4 hours, and is best performed in a room warmed by steam pipes or hot-air flues. The powder is then fit for use, and may be packed in sacks, to be afterwards placed in casks, or in double casks; sporting powder is usually packed in tin canisters.

Gun-Cotton.—(*a*) If only a small quantity is required—Mix 4½ oz. of pure, dry, nitrate of potash with 30 fl. dr. of sulphuric acid sp. gr. 1·845, and stir into this mixture carefully 120 gr. of best carded cotton. As soon as saturation is complete, in about one minute, if proper care has been used, throw the cotton into a large pan of clean rain water, and change the water repeatedly until litmus ceases to show the presence of acid, then squeeze it in a cloth, and after being well pulled out, dry it at a temperature of about 180° F.

(*b*) Take 1 oz. of cotton, 5 fl. oz. sulphuric acid, 5 fl. oz. nitric acid; mix the acids in a porcelain mortar, immerse the cotton in the mixture, and stir it for three minutes with a glass rod; decant the liquid, pour more water on the mass, and repeat the process until the washing ceases to give a precipitate with chloride of barium. Drain the product on filtering paper, and dry in a water bath.

Fulminates.— *Gold.* Add ammonia to a solution of terchloride of gold; the buff precipitate which it deposits is violently explosive at a gentle heat.

To make the terchloride of gold, dissolve gold in hydrochloric acid, with one-fourth of its volume of nitric acid. Evaporate on a water bath to a small bulk; when cool, yellow prismatic crystals of a compound of the terchloride with hydrochloric acid are deposited, from which the hydrochloric acid may be expelled by a gentle heat, not exceeding 250° F. The terchloride forms a red brown deliquescent mass, which dissolves very readily in water.

Mercury.—(*a*) This highly-explosive compound consists of protoxide of mercury united with an acid—fulminic acid, formed of cyanogen and oxygen. Fulminate of mercury is prepared by causing alcohol to react on the acid protonitrate. A quantity of mercury is dissolved in 12 parts of nitric acid of 35° or 40° B., and 11 parts of alcohol at ·86 sp. gr. are gradually added to the solution; while the temperature is slowly elevated, a lively reaction, accompanied by a copious evolution of reddish vapours, soon ensues, when the liquid, on cooling, deposits small crystals of a yellowish white colour. Fulminate of mercury is one of the most explosive compounds known, and should be handled with great care, especially when it is dry, and it detonates when rubbed against a hard body. It dissolves readily in boiling water, but the greater portion is again deposited in crystals during cooling.

The fulminating material of percussion caps is made of fulminate of mercury prepared as just stated, after having been washed in cold water. The substance is allowed to drain until it contains only about 20 per cent. of water, and is then mixed with ⅖ of its weight of nitre, which mixture is ground on a marble table with a muller of guaiacum-wood. A small quantity of the paste is then placed in each copper cap and allowed to dry, the fulminating powder in the cap being often covered with a thin coat of varnish to preserve it from moisture.

(*b*) Weigh out 25 gr. of mercury in a watch-glass, transfer it to a half-pint pipkin, add a measured ½ oz. of ordinary concentrated nitric acid sp. gr. 1·42, and apply a gentle heat. As soon as the mercury is completely dissolved, place the pipkin upon the table away from any flame, and pour quickly into it, at arm's length, 5 measured drachms of alcohol ·87 sp. gr. A brisk action will ensue, and heavy white clouds will arise. When this action has subsided, fill the pipkin with water, allow the fulminate to settle, and then pour off the liquid acid. Collect the fulminate on a filter, and wash with water as long as the washing tastes acid, then dry by exposure to the air. This explodes at a temperature of 360° F., or by being touched by a glass rod which has been dipped in concentrated nitric or sulphuric acid. An electric spark also explodes it.

Platinum.—Dissolve binoxide of platinum in dilute sulphuric acid, mix the solution with excess of ammonia; a black precipitate is obtained, which detonates violently at about 400° F.

Silver.—Dissolve 10 gr. pure silver, at a gentle heat, in 70 minims of ordinary concentrated nitric acid sp. gr. 1·42, and 50 minims of water. As soon as the silver is dissolved the heat is removed, and 200 minims of alcohol sp. gr. ·87 are added. If the nitric acid and alcohol are not of the exact strength here given, it may be difficult to start the action, in which case add two or three drops of red nitric acid which contains nitrous acid. Standard silver, containing copper, may be used for the preparation of the fulminate. If the action does not commence after a short time, a very gentle heat may be applied until effervescence begins when the fulminate of silver will be deposited in minute needles, and may be further treated as in the case of fulminate of mercury. As the fulminate of silver is exploded much more readily than the fulminate of mercury, it must be handled with the greatest caution when dry. It should be separated into small quantities, each portion, wrapped in paper, and kept in a cardboard box; nothing harder than this should be brought in contact with it. This mixture is of no use for percussion caps, being too violent in its action.

Silver and Ammonia.—Dissolve fulminate of silver in warm ammonia: the solution, on cooling, will deposit crystals of the double fulminate. This is very violent in its explosion, and is dangerous while still moist.

Modern Explosives and their Manufacture. — The following matter is extracted from a series of Cantor Lectures, delivered by Professor Vivian B. Lewes, before the Royal Society of Arts. The explosives in use may be classified into mixtures and compounds, the former class containing the combustible, and the oxygen-supplying substance in the condition of intimate mechanical mixture; whilst the latter class consists of organic compounds, containing oxygen loosely held in combination by nitrogen, the oxygen, on any disturbance of the molecular structure of the compound, entering into new combinations with the carbon and hydrogen already present in the molecule. In some of the new explosives these two classes are combined, and the gas-generating power of the second class is augmented by the admixture of highly oxidising substances, which tend to render the combustion more complete, and so increase the amount of heat generated.

Gunpowder.—Gunpowder, which is the most important and most commonly used of the explosives, is an example of the first class, being an intimate mixture of potassic nitrate or saltpetre (which supplies the oxygen), sulphur, and charcoal. Although in some of the new slow-burning prismatic powders the percentages of potassic nitrate and charcoal have been increased, and less sulphur used, the service powders of various foreign Governments approximate closely to this composition.

Country.		Potassic Nitrate.	Charcoal.	Sulphur.
England	Black powders	75	15	10
	Brown powders	79	18	3
Sweden		75	15	10
Russia		75	15	10
Prussia		74	16	10
Saxony		74	16	10
United States		76	14	10
Austria		75·5	14·5	10
France		75	12·5	12·5
Belgium		75	12·5	12·5
Germany		76	14	10

It is required of a perfect powder that when the charge is fired in the breech of the gun, the combustion shall commence comparatively slowly so as to gradually overcome the *vis inertiæ* of the projectile without throwing too great a strain on the gun, and that, as the projectile passes up the bore of the gun, the combustion shall increase in rapidity so as to supply gas more and more rapidly to increase the momentum of the shot, which should leave the muzzle of the gun with the maximum velocity. In the old fashioned grain powders this was never secured, and such powders could not have been used in the modern long bore guns, as the rapidity with which they burnt threw an enormous strain upon the breech, and would have given the maximum velocity to the projectile before it was half way up the bore of the gun, leaving friction to reduce the velocity to a considerable extent before the muzzle was reached.

The rate at which the combustion of gunpowder takes place, and at which therefore the pressure is developed, can be modified in various ways, by mechanical means. The rate can be diminished by burning the powder in the form of meal, but such a method would be inadmissible in practice, as the density of the mixture is very low and the charge would occupy too large a space.

The combustion might also be retarded by reducing the intimacy with which the ingredients are mixed, but this again would be a bad unscientific method to adopt.

The elimination of these two methods practically reduces the mechanical means for modifying the rapidity of the burning of the powder to three.

1. Varying the size and forms of the grains of powder.

2. Varying the density of the powder.

3. Varying the surface coating of each individual grain or mass, so as to retard or accelerate the ignition.

The first step was to increase the size of the grains used for cannon powder at that time, and the larger grain powder gave fairly good results with the first modified forms of guns then introduced, but as the guns and charges increased in size, this powder, in burning, became too violent, and the next step was to produce a powder in which the grains should be uniform in shape and size.

This was done by compressing the meal-powder into small moulds, so as to obtain small cylindrical pellets of about ¾ in. in diameter, and ⅝ in. in height with indentations at each end in order to increase the surface.

The manufacture of this powder was however, somewhat costly, and in order to facilitate the manufacture, a powder less regular in size than the pellet powder was produced by compressing the meal-powder into cakes, and then cutting these cakes into small cubes of about ⅝ in. and from these small cubes the charges of powder in the guns were built up, and later on experiments were made by increasing the size of these cubes until a large pebble powder, consisting of cubes of 1½ in. was arrived at.

With all these forms of powder, however, maximum rapidity of burning and evolution of gas takes place at first, owing to the ignition spreading over the whole surface of the cubes, and instead of the gas coming off with more and more rapidity as the space in the gun became larger, the evolution rapidly diminished with the decrease of surface caused by the burning away of the powder.

In order to avoid this defect as far as possible, built up charges were resorted to, and it was General Rodman, of the American Service, who first tried to overcome this difficulty by building up the charge of solid slabs perforated with holes, so as to expose the minimum surface of powder at the commencement of combustion, whilst the enlarging holes produced a greater and greater surface of powder as the space behind the projectile increased. This idea has quite lately been revived, but large perforated cakes are always liable to break, and it was found far better to build up the charge of hexagonal prisms with a central core moulded in them.

It was in accordance with this idea that the black prism powder was first made, and the increase in rapidity in combustion is due to the enlargement of the core and subsequent exposure of a larger surface, and to the fact that as the walls of the prism grow thin they break up, converting the powder during the last moments of its existence into what is practically an R.L.G. powder, thus giving enormously rapid combustion due to the exposure of a large number of fresh faces.

That this is really the case is shown by a prism being occasionally blown out with the projectile and extinguished by the sudden rush through the air, when it is seen to have been partly consumed and broken up in this way.

Finishing Methods.— Side by side with these advances in the mechanical tempering of the combustion, other advances equally great in the manufacture were being made. It was realised that in order to obtain uniformity of results, absolute uniformity of ingredients, mixing, incorporation, pressure, density and degree of dryness as well as uniformity in size must be attained, and new methods were introduced into the process of manufacture with this object in view, great attention being also paid to the "finishing" of the powder prisms and the blending together of various batches of powder which presented any variation in their ballistic properties.

Modification of Pressures.—With the continued growth, however, in the size of the guns employed, other changes became necessary, as even when using the black prism powder for built up charges the pressure given began to throw too severe a strain upon the breech of the gun, even when the cartridges were made up in such a way as to leave air spaces at the seat of the charge in order to relieve as far as possible the initial pressure.

Cocoa Powder.—In order to secure further modifications in the pressure developed, it soon became manifest that chemical alterations in the composition of the powder would be necessary. Sir Frederick Abel and Sir Andrew Noble had already made researches which conclusively showed that advantages might be secured in powder to be used in heavy guns by increasing the proportion of carbon and reducing the quantity of sulphur present, when Mr. Heidmann and Mr. Duttenhofer almost simultaneously produced a prismatic powder, in which the saltpetre was increased in quantity, the sulphur reduced, and low burnt charcoal in larger proportion was employed. This powder which received the name of "Cocoa powder," from the brown colour imparted to it by the semi-charred woody fibre, gave a considerably lower initial strain and a much longer sustained action when used in large guns.

In these powders not only did the change in the proportions of the ingredients effect a considerable alteration in their point of ignition, and rate of combustion, but the introduction of charcoal produced at a comparatively low temperature also brought into play other important considerations.

Charcoal.—The charcoal used in making powder was at one time looked upon as being practically pure carbon, but it also contains certain proportions of hydrogen and oxygen remaining from the woody fibre from which it is formed, and it moreover has the property of absorbing oxygen and moisture with considerable rapidity from the air, and the parts which these substances play in the explosion of the powder are only now beginning to be thoroughly understood.

The amount of hydrogen present in charcoal exerts an important influence upon the ease with which it can be ignited, but the presence of hydrogen and oxygen also reduces its thermal value, so that although the value of pure carbon is equivalent to 8080 thermal units, the thermal value of the charcoal used for powder making rarely exceeds 6600.

Where it is important to retain a certain proportion of moisture in powder, low burnt charcoal is of the greatest value, and the straw carbonised by superheated steam, which was used in the cocoa powder, played a most important part in imparting to the densely pressed prisms sufficient hydroscopic power to enable it to hold the necessary percentage of moisture.

Prism Powder.—The introduction of the cocoa powder was a great advance, but with the heaviest guns it became necessary to obtain even slower combustion, and by slight modifications in composition, the present service powders known as S.B.C. and E.X.E. prism were introduced.

The E.X.E. is used in the 6-inch breech loading and R.M.L. guns, whilst the S.B.C. is employed in the 68 and 110 ton guns.

The E.X.E. prism is distinguished by its slate colour and by a groove moulded round the core, whilst the S.B.C. prism is recognisable by its brown colour and by a circular indentation round the core.

In making the new prism powders the ingredients are first accurately weighed out, allowance being made for the moisture present in the refined saltpetre, and are then mixed in charges of from 50 to 60 pounds in a gun metal drum, which contains arms revolving in an opposite direction to the drum itself. The mixture is then passed through a copper sieve to make sure that no solid foreign material is present, and is then called "green charge." This is now taken to the incorporating mill, which consists of two iron or stone edge runners weighing from three to four tons, which revolve on a bed made of the same material as the runners themselves, and having a sloping rim. The runners are worked by machinery from below, and make seven to eight revolutions per minute.

The green charge is placed on the bed of the mill, and is moistened with a very small quantity of distilled water, to prevent any of the charge escaping as dust, and also to aid the incorporation.

The green charge is milled for from three to eight hours according to the nature of the powder, and a workman constantly pushes the charge from the outside to the middle of the bed plate with a wooden "shover," so as to keep it under the runners.

The incorporating mills are in a long building containing six mills, each of which is shut off from the next by a partition, whilst over each mill is an iron cistern connected by a lever arm to a large wooden shutter which is exactly over the bed of the mill; explosion of the charge would raise the shutter and deluge the mill by upsetting the tank. All the tanks work on one shaft, so that the upsetting of one would drown the charges in all the mills.

The mixture, which is now called mill-cake, is next conveyed to the breaking-down machine, where the mill-cake is placed in a hopper, and is carried by an endless band to the top of the machine and then falls between a pair of grooved rollers and afterwards between plain rollers, which break it into what is termed "meal." This meal is now packed in layers in the press-box, and is subjected to a pressure of 70 tons on the square foot for about fifteen minutes, which renders it exceedingly hard and compact, and in this condition it is called "press-cake." This is granulated by making it pass through successive pairs of grooved gun-metal rollers, which reduce it to the required size.

The prisms are now made by taking the granulated press-cake and compressing it in a hydraulic press machine into regular six-sided prisms. These prisms are made under enormous hydraulic pressure in phosphor-bronze moulds, and are perforated by a hole through the centre, so that when built up in the cartridge the flame can have free access from end to end of the whole charge.

Great attention is paid to the stoving of the new forms of prism powder —E.X.E. and S.B.C.—as the amount of moisture in them has an important bearing upon their rate of explosion, and they are dried first for 24 hours at 32°C., and then for 12 hours at 60°C., which leaves them with from 1·7 to 2·2 per cent. of moisture, which is the normal amount which these powders retain under ordinary atmospheric conditions.

A day's production at the Royal Government Factory is made in many machines, and it is manifest that not only atmospheric conditions, but also slight differences in the methods of work employed by the different men tending the machines, will make considerable differences in the batches turned out by each machine, and, if unadjusted, the batches of powder would of necessity give irregular results when used in guns.

In order to overcome this the batches of powder are blended, that is to say, the results obtained by firing a charge or charges from each batch are carefully noted, and the prisms from each batch are then mixed in such proportions as to give uniformity in the results obtained from the whole output.

Densities.—Great attention is also paid to the density of these powders, any decrease in density tending to increase the pressure.

Density.	Velocity. Feet per sec.	Pressure. Tons per sq. in.
1·790	2066	17·5
1·800	1944	14·6
1·820	1894	12·7

The way in which powder burns is influenced to a great extent by the conditions under which it is ignited; if some powder is placed in a cylinder and touched with a hot wire, it catches fire and burns with a "puff," but if the powder is heated in a test tube at a certain temperature, it explodes. In the one case the combustion spreads from grain to grain, whilst in the second case the whole mass is heated to a high temperature, and the increase in rapidity in burning is manifested by explosion. Variation in pressure has a considerable influence upon the rate at which powder will burn, as under low pressure the flame from the powder escapes so rapidly that its power of passing on the combustion from grain to grain becomes seriously impaired.

Gun-Cotton.—In the manufacture of gun-cotton, the best white cotton waste only is used, and is supplied free from all grease and dirt, which has been previously extracted by boiling it with dilute alkaline solutions; this is important, as if any greasy or resinous substances remained in the cotton, they would form compounds with the acids employed, which would be liable to cause decomposition.

The cotton is first picked over by hand, all foreign substances being removed, and it is then passed through the "teasing machine," in which rollers bearing iron teeth rotate and tear up any knots or lumps which may exist in the waste; after this it is passed through the "cutting machine," which chops it into pieces not exceeding 2 in. in length. If any moisture were present in the waste, it would cause evolution of heat on dipping it in the acids, the cotton is therefore dried by passing it through a chamber heated to about 83° C., in which the cotton placed on endless bands travels backwards and forwards for about 20 minutes; it is then weighed up into lots of 1¼ lb., called a charge, and is placed in an air-tight box, to keep it dry until it has cooled down and is ready for dipping.

The mixture of acids consists of one part by weight of nitric acid of specific gravity 1·52 to three parts by weight of 2·45 by volume of sulphuric acid of specific gravity 1·84. These are run in the right proportions into a mixing tank fitted with a lid, through an opening in which they can be thoroughly mixed by means of a stirrer, worked backwards and forwards for some minutes. Mixing the acids is attended by evolution of a considerable amount of heat, and the mixture is allowed to stand until thoroughly cool, when it is run into a dipping pan, a small cast-iron tank, holding about 220 lb. of the mixed acids, and surrounded on the outside by running water, in order to guard against rise of temperature during the formation of the gun-cotton, which would tend to increase the percentage of collodion cotton present in the finished product.

The charge of 1¼ lb. dry cotton is now taken from its tin, and is stirred as quickly as possible into the mixed acids, in which it is allowed to remain 5 or 6 minutes, it is then lifted on to a perforated shelf at one end of the dipping-pan, and the large excess of acids squeezed out by a plate worked by a lever. The 1¼ lb. of cotton which has absorbed 14 lb. of acids, is now transferred to an earthenware pot fitted with a cover, the pot being placed in running water to prevent any rise in temperature, and the charge remains under these conditions for upwards of 24 hours, when the excess of acids present completes the conversion of the cotton. The next step is to get rid of the free acids which are still present in quantity. To do this the contents of six pots are transferred to a centrifugal machine, consisting of a perforating iron cylinder made to rotate at a rate of 1200 revolutions per minute, about 10 lb. of acids being in this way separated from each charge of cotton.

The converted cotton is now placed in a cistern of water, where it is kept continually stirred in running water until it no longer tastes acid to the tongue. The gun-cotton is now again wrung out in a centrifugal machine, and is then boiled for 5 days in wooden tanks heated by steam coils, the water is wrung out as before, and finally the gun-cotton should be so far free from acid that it does not redden blue litmus. The gun-cotton is now reduced to pulp in a machine of the same construction as a paper-maker's "hollander," in which the fibre suspended in water is made to continually pass between a bed-plate and a roller, both being armed with knives, and after being pulped for 5 hours, is reduced to a very fine state of division, and then passed through a pipe into the "poaching machine." This is another large oval tank in which paddle wheels keep the pulp constantly agitated with a large volume of fresh water, which, owing to the fine state of division of the pulp, thoroughly washes every portion of it. After 6 hours in the poacher, samples of the pulp are tested, and if the requirements of the tests are satisfied, enough lime water, whiting, and caustic soda —sodic hydrate—are mixed within to leave between 1 and 2 per cent. of free alkali in the finished gun-cotton. The pulp is now drawn up by means of a vacuum pump into an iron reservoir, called the "snuff chest," in which revolving arms keep the pulp from settling, and from which measured quantities can be run off into moulds, the bottoms being made of a very fine wire gauze, that allows the water to pass through but keeps back the fine pulp, the filtration being aided by the action of a partial vacuum maintained below the moulds.

When most of the water has been in this way separated, hydraulic pressure of about 34 lb. on the square inch, is brought to bear upon the semi-solid pulp, which expels a large proportion of the remaining water, and renders the blocks sufficiently hard to bear careful handling. The moulded gun-cotton is now taken to the "press-house," where it is subjected to hydraulic pressure of about 5 tons on the square inch, which reduces it to one-third of its original bulk, making it so hard that it does not perceptibly yield to the pressure of the finger, and when dry will just sink in water.

During the process of manufacturing gun-cotton, every precaution is taken to prevent any great rise of temperature during the period when the cotton is in contact with free acid, which would lead to decomposition of the gun-cotton with evolution of large quantities of red fumes—oxides of nitrogen —and the formation of oxalic acid and other products, whilst even a small rise in temperature increases the proportion of collodion cotton present, and so detracts from the value of the finished product. In the second stage of the manufacture—from the removal of the superfluous acid in the centrifugal wringing machine to the moulding of the blocks, the object of all the operations is to thoroughly free the converted fibre from every trace of free acid, and it has been conclusively proved that it was to a great extent owing to the retention of free acid that the explosions which attended the early manufacture of gun-cotton were due. Cotton when examined under the microscope is seen to consist of minute tubes, which during immersion in the mixed acids become filled with them, and the last traces cannot be removed by any ordinary rinsing process such as was at first considered sufficient, and when such impure gun-cotton is packed in cases chemical action is maintained by the traces of acid present, the heat generated being confined to the centre of the mass by the non-conducting properties of the cotton surrounding it; the action increases very rapidly with the rise of temperature, and a point is soon reached at which the gun-cotton becomes ignited. The liability to spontaneous decomposition is much increased when cotton which has not been thoroughly cleaned, or which contains any fatty or resinous matter, is used, and also by the presence of a large proportion of collodion cotton, which is not so stable as the completely nitrated product.

This latter cause undoubtedly was a source of danger in the gun-cotton first manufactured. This was not left long enough in contact with the acids, so that complete conversion of the whole of the cotton had not taken place and some less stable products were present. The finished gun-cotton is tested and the amount of alkalinity determined; the alkaline matter present should not be less than 0·5 per cent. or more than 2 per cent.

Having tested the finished gun-cotton for alkaline matter, it is dried at a low temperature and tested for evolution of acid. This is done by taking a small portion of the finely divided substance and placing it in a test-tube with a piece of test paper, moistened with a mixture of potassic iodide and starch, and then gently heating the tube in a water bath at a temperature of 66° C. No discolouration of the paper must take place for at least 10 minutes. If there is any free acid present, nitrous fumes will be evolved which will attack the potassic iodide, liberating iodine, which at once gives an indication by forming the blue iodide of starch.

The percentage of collodion cotton present is next determined by treating a carefully weighed sample of the gun-cotton for some hours with a mixture of alcohol and ether, which dissolves the collodion cotton but not the fully nitrated product. When 50 grains of the gun-cotton are treated in this way for 3 hours, with frequent shaking, with 4 oz. of a mixture of 2 parts by volume of ether and 1 volume of alcohol, the loss of weight, due to collodion cotton dissolved out from it, should be very small. Unconverted cotton can be detected by treating the gun-cotton with acetic ether, which dissolves the converted but not the unconverted cotton fibre.

Gun-cotton differs very widely from gunpowder in its properties, requiring a much lower temperature for its ignition, as gunpowder has to be heated to a temperature of at least 250° C., whilst gun-cotton will often take fire at 136° C., and invariably does so below 204° C. Gun-cotton can be fired by striking it with a steel hammer on an anvil. The explosion, however, is confined to the portion struck, but it is very difficult to ignite powder in this way. The rate at which gun-cotton burns is dependent upon the mode of its ignition, and the conditions under which it is placed. A piece of loose gun-cotton, placed on the hand, and touched with a hot glass rod, burns away so rapidly that the skin is not scorched or burned. For the same reason, a piece of gun-cotton can be fired upon a small pile of gunpowder without igniting the powder, and grains of powder can indeed be wrapped up in gun-cotton and the gun-cotton ignited without the powder being burnt.

Rapid as this combustion is, however, it occupies an appreciable time, as may be seen by igniting a train of loose gun-cotton, which takes several seconds to burn a few feet, giving at the same time a large flame. If gun-cotton be confined at the moment of ignition this flame is forced back into the mass, and by rapidly heating it brings it to the point at which combustion passes into explosion, and prior to 1868, when gun-cotton was required for destructive purposes, it was always confined in strong cases, but in that year Mr. E. O. Brown, of Woolwich, discovered that when a detonating fuse was exploded in contact with compressed gun-cotton, the unconfined mass at once exploded with enormous violence, and this discovery of the possibility of detonating gun-cotton marks the second great stage in the history of the substance.

The fact that certain unstable compounds could be caused to undergo instantaneous decomposition by the sympathetic vibration set up in them by a sharp explosion, either in contact with or close to them, had been previously known, and Noble had exploded nitro-glycerine by detonation some years previously, but another new and most important fact was discovered nearly at the same time, namely, that gun-cotton, when wet, and containing 15 to 29 per cent. of water, could be detonated, and gave even better results than when dry, provided that a small portion of dry gun-cotton was placed in contact with the detonating-fuze, the explosion of this portion ensuring the detonation of the wet mass.

The great importance of this discovery is seen when one considers that the sudden conversion of the solid mass into gaseous constituents endows gun-cotton when exploded in this way, with an enormous destructive power, which is as great when the explosive is free as when it is confined, and that although it can be detonated when wet, in this condition it is not inflammable, and that a hole may be bored through a block of wet gun-cotton with a red-hot iron without inflaming it, a fact which renders it the safest explosive we possess, as it can be stored wet in closed vessels and dried as it is required for use, or even used wet with a small primer of dried gun-cotton.

If dry compressed gun-cotton is ignited by touching it with a hot rod, it burns away with a fierce flame, but without explosion, but if larger quantities were ignited in this way, the portions first burning would quickly heat up other parts of the mass to the temperature at which combustion becomes explosively rapid, and as soon as this point was reached detonation of the whole mass would take place.

The great increase in effect gained by detonating such explosives as gun-cotton arises from the enormous increase in rapidity of explosion. A train of ordinary gun-cotton fired by a hot rod takes several seconds to burn a distance of a few feet, but if a train of compressed gun-cotton was fired by detonation, the explosion would travel at the rate of 200 miles a minute. When gun-cotton is fired by touching it with a red-hot rod, its combustion occupies an appreciable time, and the gaseous products evolved have time to find space for themselves in the surrounding air. If, however, detonation be employed, the conversion of the solid into an enormously increased volume of gas takes place instantaneously, and the atmospheric pressure forms just as good a "tamping" for the gun-cotton as the strong metal cases which were employed before the principle of detonation was recognised.

In order to detonate gun-cotton, fuses charged with mercuric fulminate are now generally employed.

The products formed during the explosion of gun-cotton vary so greatly with the conditions under which it is fired and the proportion of collodion cotton present, that any attempt to construct an equation must be misleading.

When gun-cotton is fired under ordinary atmospheric pressure, the products of combustion are found to be carbon dioxide, carbon monoxide, marsh gas, nitric acid, nitrogen, water vapour, and sometimes traces of cyanogen and hydrocyanic acid; but as the rapidity of explosion and the pressure increase, so the products become less complex. When detonated, the gaseous products of the decomposition are—

—	Dry Gun-Cotton.	Wet Gun-Cotton.
Carbon dioxide .	24·24	32·14
Carbon monoxide	40·50	27·12
Hydrogen . .	20·20	26·74
Nitrogen . . .	14·86	14·00
Marsh gas . .	0·20	None
	100·00	100·00

Estimations of the pressure developed by the detonation of gun-cotton differ greatly in value, Berthelot placing it as high as 24,000 atmospheres, or 160 tons on the square inch, whilst other authorities estimate it as not much more than half this pressure.

The experiments of Sir Frederick Abel show that the detonation of moist gun-cotton is rather quicker than of dry, whilst the work done by the same weight of cotton appears to be equal in either case. The presence, however, of water in the moist gun-cotton must use up a certain amount of the heat, but this will be accompanied by an increase in the volume of the gases owing to the extra hydrogen liberated. It has been proposed to soak the gun-cotton in paraffin instead of water in order to get over the trouble of evaporation, and this has been tried with fairly satisfactory results, but the addition of a hydrocarbon to a substance already containing too little oxygen for its complete combustion seems hardly advisable.

Nitroglycerine.—In the manufacture of nitroglycerine, a mixture of 992 lb. of nitric acid, sp. gr. 1·48 and 1680 lb. of sulphuric acid, sp. gr. 1·84, is thoroughly cooled and run into the mixing vat made of chemically pure lead, all the joints of which are autogenously melted together. The glycerine is then slowly and carefully added by means of an injector which regulates the rate of supply, whilst the whole charge is kept well agitated by blowing air through it, which not only thoroughly mixes the glycerine and the acids but also prevents local heating. In this way 330 lb. of glycerine are mixed in with the acids, the process taking about an hour, and every precaution is taken to prevent the temperature rising above a limit of 22° C. (71·6° F.), the mixture being cooled by cold water, which is run through a coil of lead pipes inside the vat. If by any chance the temperature should rise to a higher limit, a valve in the bottom of the vessel can be opened, and the whole charge run into a tank of water placed below it.

As soon as the nitrating is completed, the charge is run into a second lead tank or vat, and allowed to stand for an hour, when the nitroglycerine separates, and rises to the top of the mixed acids. When the separation is completed, the acids are drawn off, and the nitroglycerine is run off into lead vessels, where it is first washed with water and then with a solution of soda. The washing process is then repeated three times with hot water and soda, and after separating from the wash water is filtered through table salt and run into the store tanks.

Nitroglycerine so prepared is an oily colourless liquid, which has no odour and is insoluble in water, although it rapidly dissolves in ether, benzol, wood spirit, and hot alcohol, and from the solution so formed can again be precipitated on dilution with water.

It has a violent effect upon the system, acting in large doses like strychnine, whilst even traces produce vertigo, and as it is absorbed through the skin, people working with it are frequently at first seriously affected, but after a time, experience no ill effects, and, it is said, present a more than usually healthy appearance. When cautiously heated to 100° C. it slowly evaporates, at 200° C. it burns, and detonates at 257° C. When a lighted match is applied to it, it burns quietly away, and, when the light is removed, the flame generally goes out; indeed a lighted match may be extinguished by plunging it into nitroglycerine. It is, however, detonated by a sudden blow, or by heating it to 257° C. Nitroglycerine becomes solid at 4° C., but so much depends upon the length of exposure to cold that this may happen at from +8° C., to −11° C., and in this condition it is comparatively inert, hence it is necessary to thaw it before use, an operation attended with considerable risk. It is stated that the exposure to the direct rays of the sun will convert it into a very unstable and explosive substance, and also that the presence of ozone will sometimes cause its spontaneous decomposition.

Dynamite.—The nitroglycerine preparations to which Nobel gave the name of dynamite may be divided into two classes; first, those containing non-explosive absorbents; and, secondly, those with explosive absorbents, the majority of these will be considered under the heading of blasting explosives.

When first working in this direction in 1866, Nobel used charcoal as an absorbent for nitroglycerine, and, encouraged by the success of his experiments, tried various other bodies which were capable of taking up and holding the nitroglycerine, and he came to the conclusion that the infusorial earth first found at Oberlohe, in Hanover, gave the most satisfactory results. This earth consisted of the remains of diatoms, and contained 95 per cent. of silica, which is so finely divided as to be free from any grit, and which, after having been heated to a moderate temperature to remove moisture and organic matter, can be ground and sifted.

This substance is called kieselguhr, and is mixed with three times its weight of nitroglycerine, the mixture being made by hand-kneading. It is sometimes squeezed by hand through the meshes of a coarse sieve, and sometimes is forced out of a metal tube by means of a peculiarly constructed Archimedean screw, the resulting mass being cut into lengths to form cartridges of the required size.

During the mixing of the substance, 8 per cent. of sodic carbonate, baric sulphate, mica, talc, ochre, and ammonium carbonate are allowed to be added to it. This substance is generally known by the name of dynamite No. 1. In the large factory at Ardeer, the kieselguhr employed comes from Aberdeenshire, and is of considerable purity containing 98 per cent of silica, whilst in France a similar earth, called "Randanite," is employed.

The finished dynamite is a semi-plastic substance of a reddish-brown colour containing 75 per cent. of nitroglycerine, and has a specific gravity, as made at Ardeer, of about 1·6. Under normal conditions dynamite can be set fire to by the application of a flame, and even when in considerable quantity can be burnt in this way without explosion, but, like nitroglycerine, if the temperature rises above a certain limit, the combustion increases in rapidity until the temperature of detonation is reached.

Dynamite, like nitroglycerine, freezes at a temperature of about 4° C. The frozen cartridges are less sensitive to shock and detonation, and therefore have to be thawed before use for blasting purposes, and it has been found that frozen dynamite burns very slowly, the first portion of the heat being used to thaw the substance before combustion takes place, but the burning frozen dynamite cartridges are much more likely to explode than when the dynamite is in its ordinary state.

Carbodynamite. — One of the great troubles with kieselguhr dynamite is that under certain conditions some of the nitroglycerine will exude from it, this being specially the case when wet or placed in water, and in 1866 Mr. Walter Reid utilised the idea of making dynamite in which low burnt charcoal made from cork rich in hydrogen is used as the absorbing material instead of kieselguhr, and the absorbing power of this charcoal is so great that a dynamite can be made containing only 10 per cent. of the cork charcoal and 90 per cent. of the nitroglycerine, which is retained with such power by the absorbent nature of the inert material that it can be kept for years under water without losing its nitroglycerine, whilst the high percentage of explosive gives it a greater intensity of action than is the case with the kieselguhr dynamite.

This preparation is called carbodynamite, and the inventor claims that it can be made absolutely uninflammable by the incorporation with it of one-fourth its weight of water, which can easily be kneaded into it, and that in this state it can still be exploded by the use of a sufficiently powerful detonator.

Schultze Powder.—The Schultze powder consisted of granulated wood which, after purification by boiling with dilute sodium carbonate, was washed and treated with a solution of bleaching powder ; the mass was then washed, dried, and soaked in the mixture of strong nitric and sulphuric acids for two or three hours, the temperature at the same time being kept as low as possible, and after getting rid of the free acid in a centrifugal machine, the nitrated wood was washed with water until free from acid, boiled with dilute sodium carbonate, and dried, after which it was steeped in a solution of the mixed nitrates of barium and potassium, and again dried at a low temperature. This powder attained a considerable popularity for sporting purposes.*

E.C. Powder.—Another powder which became very popular for sporting purposes was the well-known E.C. powder, which was first made by Mr. Reid in 1882, and consisted of gun-cotton incorporated with 35 to 40 per cent. of the mixed nitrates of barium and potassium, the mass being granulated and gelatinised by means of mixtures of ether, alcohol, and benzoline, which gave a hard coating to the grain. In this powder the presence of gun-cotton constituted a source of trouble, as the action was occasionally unduly violent, and the hard coating resisted ignition by the flash, and necessitated the use of a powerful cap.

In 1888, the E.C. powder No. 2 was introduced by Mr. W. D. Borland, and in this powder the use of true gun-cotton was entirely done away with, the nitrocellulose being completely soluble, and the hardness of the grain was obtained by treatment with a solvent containing camphor, which acted uniformly throughout the mass, whilst it left the surface in a slightly roughened condition, which enabled the flash to rapidly ignite the powder.

These powders gave very satisfactory results for sporting purposes, and also gave good ballistics with smooth-bore guns, but both the E.C. and Schultze powder left an ash which was considerably harder than that afforded by the old black powder, and which instead of forming a partial lubrication for the succeeding shot, tended to choke rifled guns, so interfering with accuracy in shooting. Moreover, these powders could not be made on a large scale with a sufficient degree of uniformity to fulfil the requirements of service powders,

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* Slight modifications have from time to time been introduced into the manufacture, and even within the last year I believe hardening of the surface by treatment with ether and alcohol has been resorted to.

Smokeless Powders. — The smokeless powders which have been introduced for use in the small calibre rifles may be classified under two headings :—

1. Those consisting of nitrocellulose gelatinised, with or without the addition of nitro-benzene.
2. Those consisting of nitrocellulose gelatinised with nitroglycerine, to which have been added aniline, camphor, vaseline, and other substances of the same kind.

To the first class belong the B.N. powder manufactured by the French Government, which consists mainly of gelatinised nitrocellulose, as also does the German Trodisdorf powder, the surface of which however is coated with graphite.

Rifelite made by the Smokeless Powder Company apparently consists of nitrocellullose made from woody fibre, and gelatinised by acetone and nitrobenzene, whilst the sporting powders made by this company are of much the same character.

The Russian smokeless powder is also nitrocellulose, converted into a horn-like mass by a suitable solvent, and the German small arm powder is of much the same character, camphor also being used.

Two powders of this class are made in America, one being "Indurite," in which insoluble nitrocellulose is gelatinised with nitrobenzene, and the second the "Dupont powder," of much the same composition granulated by a special process.

The methods by which the conversion of the powder components into the finished explosive is attained vary considerably, but in most cases the processes are simple, and consist in first kneading together the nitrocellulose with the solvent in a machine of the same character as those used in large bakeries for kneading the dough. These consist of iron cases, in which shafts rotate carrying screw blades revolving in opposite directions, which cause thorough incorporation and kneading of the substance placed in them. This operation might at first sight appear fraught with some danger, but the mixture of the nitrocellulose with the solvent is practically non-explosive, so that there is no risk unless actual flame is brought in contact with the mass.

The length of time taken in the kneading process varies from three to ten hours, according to the mass of solvent which is employed, a larger quantity requiring far less time than when only a small quantity is used. When this kneading and incorporation is completed, the mass has a soft consistency, and is generally semi-translucent, and is then ready for moulding into the form of the finished powder. In some cases the mass is converted into grains by suspending it in hot water and blowing steam into it, which disintegrates the mass, and causes it to become granular. In other cases it is squeezed into threads or rolled out into sheets.

The largest proportion of the powders are made in this latter form, the kneaded mass being rolled out into sheets by means of rollers heated by steam, so as to drive out from the mass the solvent, at the same time that the thin sheet is produced, the temperature employed of course depending upon the boiling point of the solvent liquid. These sheets are then cut up into small squares or pieces of the required size in a cutting machine, whilst if the powder is required rather in the form of cubes than in flat flakes several sheets of the explosive are superimposed upon one another and luted together by means of a fitting cement, and the mass is then cut into the required size.

This is necessary, as if the sheet were originally made of the required thickness, it could not be obtained uniform in density, and would always contain a number of air bubbles, whilst at the same time the solvent could not be properly eliminated.

Ballistite.—In January 1888, Mr.

Nobel took out a patent for using nitrocellulose mixed with nitroglycerine, with or without the addition of a retarding agent, to form a powder which could be relied upon for use in guns.

It had been found by experiments made in Austria for putting blasting gelatine to military purposes, that this substance might be exploded by the penetration of a bullet or fragments of a shell into the transport waggon, and Colonel Hess, whilst endeavouring to make it less susceptible to accidental explosion, found that by incorporating with the components a small proportion of camphor, and also by increasing the proportion of nitro gun-cotton used, the rapidity of the explosion of the material could be reduced, and the product made of a horn-like character, which had remarkable ballistic properties, and which was uniform and practically smokeless.

Some of the camphor, however, used in the substance remains in it, and this being volatile, its evaporation causes modifications in the ballistic properties of the powder, and attempts have been made to improve upon this by replacing the camphor by other substances which would play the same part as the camphor, and which would not have the same drawbacks.

The powder so made by Nobel, and known by the name of ballistite, is extensively used in Italy and Germany. As manufactured in Italy, it contains equal parts of nitrocellulose and nitroglycerine, with the addition of a ½ per cent. of aniline, and when used in the form of threads or cords is called "Filite." The German ballistite contains a rather larger percentage of nitrocellulose, and the finished material is coated with graphite.

In making the ballistite, the original method was to absorb the nitroglycerine by the collodion cotton in a vacuum vessel, and having pressed out the excess of nitroglycerine, to warm the remainder in order to dissolve the collodion cotton, but a far simpler device has since been introduced by Messrs. Lundholm and Sayers, by which the solution of the nitrocellulose and the glycerine is rapidly brought about.

If the nitrocellulose be slightly moistened, its solubility in nitroglycerine is very greatly retarded, but if the nitrocellulose be suspended with nitroglycerine in warm water, and the mass then agitated by blowing air through it, the incorporation of the nitroglycerine and the nitrocotton takes place with considerable rapidity at a temperature of about 60° F.

When the incorporation is completed, and the mass thoroughly gelatinised, a large proportion of water is removed by pressure, and the mass is then rolled into sheets under heated rollers, and cut to the required size of flake and dried in the usual way.

In these powders the collodion cotton (dinitrocellulose) is employed, as it was well known that nitroglycerine alone does not dissolve the trinitrocellulose; but whilst endeavouring to avoid slight imperfections which had been noticed in the behaviour of the ballistite, Sir Frederick Abel and Professor Sir James Dewar found that if trinitrocellulose and nitroglycerine were mutually taken up by a liquid capable of dissolving them both, on evaporating off the solvent, the trinitrocellulose and the nitroglycerine remained behind in the most perfectly incorporated and gelatinised condition, and it is to this principle that we owe our English smokeless service powder. Cordite, which contains 58 per cent. of nitroglycerine, 37 per cent. of trinitrocellulose, and 5 per cent. of vaseline.

Cordite.—The gun-cotton employed in the manufacture of cordite is made at Waltham Abbey by the same process as described, the only difference being that no lime-water, caustic soda, or whitening is added in the last "poaching," and after moulding the pulp is only subjected to a pressure of about 40 lb. on the square inch, and, after the process, still contains about

40 per cent. of moisture, which is afterwards "stoved" down to 0·5 per cent. If the gun-cotton had been pressed as in making torpedo slabs, under a pressure of 4000 lb. to the square inch, it would have been too dense to have been afterwards properly acted upon by the acetone and nitroglycerine in making the cordite.

After the gun-cotton has been dried in the stoving-house at 100° F., it is taken to the nitroglycerine store in a covered trough, and the right proportion of nitroglycerine is poured upon it, and the two substances lightly mixed by hand so as to ensure complete absorption of the nitroglycerine by the gun-cotton.

The mixture is now taken to another house, where it is put into a kneading machine, in which slowly revolving blades incorporate the solvent acetone with it, and keep it thoroughly mixed and kneaded whilst the solvent action is proceeding. As this action approaches completion, petroleum jelly or vaseline is added, and the whole charge is incorporated in the machine for 7 hours, and is then ready for pressing. Strong gun-metal cylinders are charged with the mixture under low hydraulic pressure, and these cylinders are then placed in position in the pressing machine, where a rammer of steel driven by a screw presses upon the mixture and drives it out through a small hole in the bottom of the cylinder as semi-gelatinous cords or threads of the required size. As these leave the machine they are supported on a running web, and cut automatically into required lengths, which are arranged for drying in shallow trays. The smaller sizes are wound on large reels, and when these are filled with the cordite they are, like the larger sizes, taken to the drying-house and exposed to a temperature of 100° F., which drives off the acetone and renders the threads tougher. The finished cordite is now blended by mixing a number of batches together, and the substance is then ready for making into cartridges.

Acetone, which is used in making the cordite and also as a solvent in some other smokeless powders, is a compound having the formula C_3H_6O. It is a colourless fragrant liquid, having a specific gravity of 0·81 and boiling at 56·3° C. or 133·3° F. It is inflammable, and burns with a luminous flame, and will mix with water, alcohol, and ether. It is essential for purposes such as the making of smokeless powders, that it should be as pure as possible, as any traces of impurity would probably be left behind on its evaporation, and remain in the powder. That used at Waltham Abbey has a specific gravity of 0·7965, and 98 per cent. of it distils off between 56·2 and 56·4° C. When such acetone is treated with a 0·1 per cent. solution of potassium permanganate, it should retain its rose colour for more than 2 minutes, and the Waltham samples will generally do so for nine. In addition to this point, it should not have more than 0·005 per cent. of acidity nor contain more than 0·1 per cent. of aldehyde. Vaseline or mineral jelly used is obtained during the distillation of petroleum, and consists mainly of portions distilling at temperatures above 200° C.; it has a boiling point of about 278° C., and has been given the formula $C_{16}H_{34}$. Cordite burns when ignited in air and leaves no residue, and gives practically no smoke. It is not nearly so sensitive to percussive detonation as gun-cotton, though perhaps a little more so than gunpowder, and it is so difficult to ignite in a gun that a primer of R.F.G. black powder has to be employed. When a rifle bullet is fired into cordite, it burns quietly.

It is unaffected by both frost and salt water, but when exposed for any length of time to the latter, it is better that it should be washed with fresh water and carefully dried at a temperature below 100° F. before being stored.

Sprengel Explosives. — Dr. Sprengel showed that mixtures of potassium chlorate and such bodies as benzine, petroleum, and phenol could be detonated and exploded with great violence. This class of explosives, named after the inventor, "Sprengel explosives," has been largely adopted for blasting purposes, The principal are :—

Rack-a-rock, a mixture of potassium chlorate and petroleum, or, in some cases, nitrobenzol, which obtained notoriety from being the material used in the Hell-gate explosions, when the rocks at the mouth of New York Harbour were destroyed.

Hellhoffite, a mixture of nitrated tar oils with the strongest nitric acid.

Oxonite, containing picric acid and nitric acid, which are mixed just before use.

Roburite.—The Sprengel explosives have been largely used for blasting purposes, both abroad and in this country; those used here consist of mixtures of nitrated hydrocarbons and ammonium or potassium nitrate. Roburite, introduced by Dr. Carl Roth, is a simple mixture of nitrate of ammonium with chlorinated meta-di-nitro-benzol. The nitrate of ammonium is first dried and ground, then heated in a closed steam-jacketed vessel to a temperature of 80° C., and the melted organic compound is added, and the whole stirred until an intimate mixture is obtained. On cooling, the yellow powder is ready for use, and is stored is air-tight canisters, or is made up into cartridges. Owing to the deliquescent nature of the nitrate of ammonium, the finished explosive must be kept out of contact with the atmosphere, and for this reason the cartridges are waterproofed by dipping them in melted wax.

This mixture is not exploded by ordinary percussion, firing, or electric sparks. If a layer of the explosive is struck a heavy blow with a hammer, the portion directly receiving the blow is decomposed, owing to the heat developed, but no detonation whatever takes place, nor are these portions of the substance around the spot struck in any way affected, whilst, if roburite be mixed with gunpowder and the gunpowder be then ignited, the latter explodes and scatters the roburite without firing it.

The roburite can only be exploded by a specially powerful detonator, and on decomposition the gases evolved contain no combustible constituents, but consist only of carbon dioxide, water, and nitrogen, with a small trace of hydrochloric acid gas, which is at once condensed by the large volume of water vapour evolved, and gives rise to no inconvenience.

Ammonite is another explosive of this class, which is manufactured from ammonium nitrate and dinitronaphthalene, these substances being blended in the proportions to give, as the products of combustion, carbon dioxide, water vapour, and nitrogen, but during the decomposition taking place, probably some more complex action occurs, as small traces of ammonia can generally be detected.

Naphthalene, $C_{10}H_8$, which is obtained from coal-tar, and which is, perhaps, better known as the "albocarbon," employed in certain forms of gas-lamps, is acted upon with strong nitric acid, with the replacement of two equivalents of the hydrogen by the NO_2 radical. The resulting compound is then carefully freed from acid, and is then ready for use. Ammonium nitrate, carefully dried, is then incorporated with it by heavy edge-runners in mills, which are heated by steam and which are also fitted with arrangements by which the temperature of the charge can be controlled. One hundred and fifty pounds of this mixture are ground in this way until the required degree of fineness and incorporation is arrived at, and the mixture, whilst warm, is passed through a sifting-machine, which separates any particles not sufficiently ground, which are returned to the mill. The finished explosive is then ready for making up into cartridges, and the temperature is kept constant until the whole of the operations are finished.

The cartridge-cases consist of solid-drawn tubes of a lead and tin alloy, in which the compound can be kept from the action of the atmosphere upon the deliquescent ammonium nitrate, and when the cartridge is required to be prepared for firing, a part of the metal tube at the end of the cartridge is cut off by a special tool, and the detonator with fuse attached inserted, the soft metal of the tube being pressed tight round the fuse. This substance, like roburite, only explodes when detonated by a strong charge of fulminate of mercury.

Bellite which was patented in 1885, consists of a mixture of dinitrobenzene with ammonium nitrate, the latter being kept rather in excess.

Securite consists of ammonium nitrate and dinitrobenzene, but from the proportion of nitrate used it is probable that carbon monoxide is produced. These cartridges are coated with nitrated resin, in order to protect them from the action of the atmosphere.

Another class of mining explosives consists of nitroglycerine absorbed by various substances, which will render it less liable to accidental detonation.

Dynamite No. 1 consists of nitroglycerine absorbed by kieselguhr, and this has been discussed.

Dynamite No. 2 consists of nitroglycerine absorbed by a mixture of potassium nitrate and charcoal, the whole being kept homogeneous by the addition of 1 per cent. of solid paraffin or ozokerit.

Lithofracteur is composed of nitroglycerine mixed with an equal weight of a mixture of sawdust, kieselguhr, and baric nitrate, and generally also contains a small trace of sulphur.

Carbonite consists of 25 parts of nitroglycerine mixed with no less than 40 parts of wood meal, and about 34 parts of sodic or potassic nitrate, and 1 per cent. of sulphur.

All these mixtures, unless properly protected, are liable to the great drawback of occasionally exuding nitroglycerine, especially if water be present, and then they become highly dangerous to use, whilst another serious drawback is their liability to freeze, which will take place by continued exposure to a temperature of 4° C., or even slightly higher.

The other class of dynamite explosives, namely, nitroglycerine absorbed by an explosive agent, was invented by Mr. A. Nobel, who discovered that nitrated cotton would dissolve in nitroglycerine with the formation, of a solid product. In practice, 93 parts of nitroglycerine are heated in a copper water bath to about 35° C., and 7 parts of nitrated cotton —a mixture of mono- and dinitrocellulose — stirred in gradually. As the cotton dissolves the mixture gelatinises, and on cooling solidifies. This substance, called "blasting gelatine," is semi-transparent, of specific gravity 1·5 to 1·6, and is not altered by submergence in water. It freezes at 40° C., but, unlike kieselguhr dynamite, it is very easily exploded in this state by shock. A bullet may be fired through a heap of unfrozen cartridges of blasting gelatine without any explosion, whilst similarly fired through frozen cartridges it never fails in exploding them.

Gelatine Dynamite and *gelignite* are prepared by adding potassic nitrate and wood meal to the blasting gelatine in varying proportions.

The addition of 4 per cent. of camphor to the blasting gelatine increases the solidity, and at the same time makes the mixture less sensitive to shock. A preparation is made and sold under the name of camphorated gelatine. Nitromagnite, dynamagnite, forcite, Giant powder, Vulcan powder, Atlas powder, Judson powder, Hercules powder, and Lignin dynamite, are all modifications of the above forms of dynamite and blasting gelatine that have been used here or abroad.

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FILES.

SHARPENING AND RECUTTING.

(1) For files choked with grease, dirt, lead, solder, etc., make a strong solution of caustic soda, and boil the files in this. The impurities will be dissolved out, after which the files should be rinsed in water, scrubbed with a file-card, then washed in hot water, and dried quickly.

(2) For files having the teeth choked with metals such as copper and brass, let them be treated to the soda solution just referred to, then put them in a solution made of 1 gal. of water, into which is mixed a pint of nitric acid, and a ¼ pint of muriatic acid. This pickle is always desirable for files which have blunted teeth, for it has an etching effect which roughs up the edges, and makes them serviceable. It is the best plan to pass the files through the soda solution after the acid treatment, to neutralise the acid, and prevent rapid rusting.

(3) To clean files immerse them in paraffin oil for 12 hours, then clean with a file-card.

(4) Cleanse the file from all foreign matter, and then dip it into a solution of 1 part nitric acid, 3 parts sulphuric acid, and 7 parts water. The time of immersion will be according to the extent the file has been worn, and the fineness of the teeth, varying from 5 sec. to 5 min. On taking it out of the mixture, wash in water, then dip in milk of lime; wash off the lime, dry by a gentle heat, rub over equal parts of olive oil and turpentine, and finally brush over with powdered coke.

(5) Dissolve 4 oz. of saleratus in 1 qt. of water, and boil the files in it for half an hour; then remove, wash, and dry them. Now have ready, in a glass or stoneware vessel, 1 qt. of rain-water, into which you have slowly added 4 oz. of best sulphuric acid, and keep the proportions for any amount used. Immerse the files in this preparation for from 6 to 12 hours, according to fineness or coarseness of the file; then remove; wash them clean, dry quickly, and put a little sweet oil on them to cover the surface. If the files are coarse, they will need to remain in about 12 hours, but for fine files 6 to 8 hours is sufficient. This plan is applicable to blacksmiths', gunsmiths', tinners', coppersmiths', and machinists' files. Copper and tin workers will only require a short time to take the articles out of their files, as the soft metals with which they become filled are soon dissolved. Blacksmiths' and saw-mill files require full time. Files may be recut three times by this process. The liquid may be used at different times if required. Keep it away from children, as it is poisonous.

(6) In giving worn files the acid treatment, they are first freed from grease by scratch-brushing with the use of potash or soda lye. They are then laid in an oblong box of a material not attacked by acids, a few glass rods or varnished sticks of wood being first placed upon the bottom. The files being laid alongside each other, sufficient cold water to cover them is poured into the box, one-eighth part of concentrated nitric acid is then added, and after mixing water and acid by moving the box, the whole is allowed to stand quietly for 25 minutes. The files are then taken from the bath, thoroughly scratch-brushed with the use of water, and replaced in the box for 25 min., the bath having previously been strengthened by an additional eighth part of nitric acid. During this operation care must be used to turn the files, and to see that they are entirely wetted with the fluid. The files are then taken from the bath, thoroughly cleansed with scratch-brush, and replaced in the bath, to which previously the sixteenth part of concentrated sulphuric acid has been added. The bath now becomes heated, and red-brown vapours escape. Keep the box rocking so that the acids may act as uniformly as possible. After 5 min. the files are again taken out, cleansed,

and then replaced for 5 min. more in the same bath, previously strengthened by the addition of one-sixteenth part more of concentrated sulphuric acid; keep the bath constantly rocking. The operation is now finished, the files being finally scratch-brushed, and, for the removal of every trace of acid, placed in a vessel with water in which is some fresh quicklime, which gives them a good colour. They are then rinsed in clean water, dried over a spirit-flame, and rubbed with a little oil.

(7) An American patent refers to the process of sharpening files by the use of acid, the specification saying that "In carrying out the method, it has been found that notwithstanding a thorough cleansing of the files in soap and soda, and rinsing in water, the nitric acid in many cases was acting slowly and irregularly in attacking and biting away the bottom and sides of the teeth. The object of my improvement is to render the action of the nitric acid more certain and regular. For this purpose, after washing and brushing the files with soap and soda, and rinsing them in water, I immerse and pickle them for about ½ hour in diluted sulphuric acid, 1 part of commercial acid being mixed with about 4 parts of water. The sulphuric acid slightly corrodes or attacks the surface of the file, and prepares it for the subsequent action of the nitric acid, imparting a surface to the file which enables the subsequent process to operate more certainly and efficiently, and to produce a greater and more uniform sharpness of the tooth than when such preliminary pickling is not applied. With the same object after pickling the files in sulphuric acid, as aforesaid, I also draw the point of a needle through all the grooves, in consequence of which the nitric acid is enabled to act more certainly at this point, and bite away the sides of the teeth from the bottom towards the top. After cleaning and drying the files, I coat the worn or flat tops of the teeth with varnish, such as Brunswick black, capable of resisting the corrosive action of acids, and immerse them in a mixture of nitric acid and water till the bottom and sides of the teeth are bitten away sufficiently to throw off the flat tops, leaving the newly-formed teeth very sharp. ('American Machinist.')

(8) Sharpening files with the sand blast consists in forcing with great rapidity a jet of fine sand against the file to be sharpened by means of a jet of steam. The file is presented to the jet of sand at an angle of from 40° to 50°, and so moved that the jet of sand gradually strikes the entire surface. The sand used for the purpose must be very fine and sharp and well washed.

(9) The following process is useful in preventing the breaking out of the teeth as much as is possible: Fill an iron vessel 30–40 in. long, 6–8 in. wide and of a corresponding depth with water. Boil the contents of a boiler over a fire, which should strike only the bottom of the boiler. Now add to the water 8 oz. of white soap, previously dissolved in warm water, and 4 oz. of potash. Then pour in colza oil until the entire surface of the contents of the boiler is covered. The hardened and cleansed files, secured to suitable iron wires, are then immersed in the boiling fluid for 2 or 3 minutes, when they are taken out and laid upon a table or a board. By the heat communicated to the files the water soon evaporates, whilst the oil soon penetrates the teeth. The result of this is to make the teeth somewhat elastic and less likely to break.

(10) Until recently resharpening has been done by recutting the grooves in machines devoted to that class of work, but lately the sand blast has been most successfully applied to the purpose. The operator holds the files which have to be sharpened, one at a time, in a long gas-pipe handle, into the end of which has been driven a plug of wood; the file is not held still, but is moved to and fro, resting upon

a slip of gun-metal, the file being also occasionally turned over. The slip not only forms a rest, but as the operator moves the file backward and forward upon it he learns when the file has reached a good cutting state. As far as the sharpening is concerned, this is the whole operation. It will be easily understood that a little practice is necessary to enable a man to make the best job of a file. In Fig. 130, *a b* are sections of file teeth. *a* shows the form of the teeth as they come from the file cutter or machine. From this it will be seen that the upper part of the tooth is turned backward somewhat, and the top is rather weak. The effect of the sand blast is to remove this bent-over or rounded top, and to take off the tops of the extra high teeth. The form then is as shown at *b*. It might be expected that the sand would cut the point or fine edge of the teeth, but this is not the case, for smooth files are improved as much as those of the coarser descriptions. The sand used is exceedingly fine, and is the waste material resulting from the grinding of plate glass. It is so fine as to be like smooth, clean mud, and it seems remarkable that this will do the work. In the ordinary way, cleaning files after the hardening and tempering processes is a dirty, laborious operation. They have to be scoured with brushes and sand by hand, then put into lime-water, and dried. By one workman, only about 3 doz. per hour can be cleaned. It is an accident of the sand-blast process that it cleans the files as well as sharpens them. As they pass from the sand-blast hand they go to a boy, who passes them under a jet of hot water, which cleans out sand sludge, and, the file being then hot, it dries of itself. Before the use of the hot-water jet, one man used to be employed in brushing the dried sand mud out of the files at the cost of one man for each machine and 6*s.* per week for brushes. Now a lad does all. With one machine, 14-in. files may be sharpened at the rate of —flat bastard, 5–8 doz. per hour; second cut, 10–12 doz.; smooth, 12-15 doz.; half round bastard, 4–6 doz.; ditto second cut, 8–9 doz., and so on. The apparatus is now being used a good deal to sharpen worn files, which it does at a very low cost.

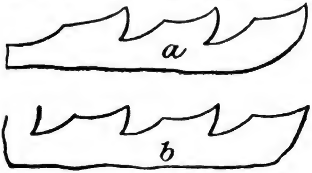

FIG. 130.

(11) Files can be recut by cleaning them, and placing them in acidulated water between two plates of carbon, and closing the circuit so as to form a real voltaic cell. The hydrogen liberated clings to the points of the file, protecting them from further action, but the cutting action proceeds freely over the remainder of the file. This process speedily brings back the teeth of an old file to the original shape and dimensions, and does not merely sharpen them but practically recuts the file, without necessitating either softening or retempering the metal.

(12) Treatment with acid may be effected by means of a galvanic battery, the bath, which is composed of water, 100 parts; nitric acid, 80; and sulphuric, 40, being connected with the positive pole. The negative pole is formed of a copper spiral passing around the files without touching them, and with the end pointing towards the surface of the fluid. By using a galvanic battery of 12 Bunsen elements 10 minutes suffice for the treatment.

(13) Carefully clean them with hot water and soda, then place them in connection with the positive pole of a battery in a bath composed of 4 parts of sulphuric acid and 100 parts

water. The negative pole is to be formed of a copper spiral, surrounding the files but not touching them; the coil terminates in a wire reaching above the surface. Leave the files in the bath 10 minutes, then carefully wash them off, dry, and oil.

◆

FILTRATION AND PERCOLATION.

(*See also* LABORATORY APPARATUS, RAIN-WATER SEPARATORS, ETC.)

IN general terms, the object of filtration may be said to be the separation of the solid from the liquid constituents of a fluid mass by means of a straining medium. Either the solid portion, or the liquid portion, or both, may be the valuable ingredient. As different processes and apparatus are employed according to the character of the fluid to be filtered, it will be convenient to divide the subject into several heads.

Water. — Water is undoubtedly the most important fluid submitted to filtration. In this case, the operation is destined to perform 3 distinct functions, at least where the water is required for domestic use; these are (1) to remove suspended impurities, (2) to remove a portion of the impurities in solution, and (3) to destroy and remove low organic bodies.

The first step is efficiently performed by nature, in the case of well and spring water, by subsidence and a long period of filtration through the earth; in the case of river water supplied by the various companies, it is carried out in immense settling ponds and filter beds of sand and gravel. This suffices for water destined for many purposes. The second and third steps are essential for all drinking water, and are the aim of every domestic filter. The construction of water filters may now be discussed according to the nature of the filtering medium.

Gravel and Sand.—(*a*) The usual plan adopted by the water companies is to build a series of tunnels with bricks without mortar; these are covered with a layer of fine gravel 2 ft. thick, then a stratum of fine gravel and coarse sand, and lastly a layer of 2 ft. of fine sand. The water is first pumped into a reservoir, and after a time, for the subsidence of the coarser impurities, the water flows through the filter beds which are slightly lower. For the benefit of those desirous of filtering water on a large scale with sand filtering beds, it may be stated that there should be 1½ yd. of filtering area for each 1000 gal. per day. For effective work, the descent of the water should not exceed 6 in. per hour.

This simple means of arresting solid impurities and an appreciable portion of the matters in solution, may be applied on a domestic scale, in the following manner.

As just mentioned, after being allowed to rest in what is termed a "settling-bed," so that the coarser and heavier impurities held in suspension, may settle down by their own weight, the water is allowed to flow on to the top of the sand filter bed and percolate through, this action removing the remaining suspended impurities. It is stated, as a disadvantge, that downward filtration, as this is, is too rapid, and is more likely to carry impurities through than upward filtration. With the latter, it is considered that more perfect results are obtained as the flow of water is said to be slower and the tendency is for the suspended matter to fall away from the filter bed instead of being carried through it. In practice, however, these advantages are not apparent. In regard to the speed of flow through the filter there may, or may not, be a difference when the water is first run into the filter chamber, but once it is filled the flow either way is controlled by the quantity of water drawn and must be about the same whichever way the water has to travel. This is the correct way of looking at this detail as the normal condition of the filter is to be full of water. In regard to the impurities being carried through the bed by downward filtration, there is some weight in this, though it does not occur to a serious extent. If it is a small fault, it is more than counterbalanced (and overcome) by the advantages of the state of the filter bed being always visible and the ease with which it can be cleaned. With upward filtration, there is nothing to indicate the state of the bed in regard to its cleanliness ; and, when cleaning is necessary, the whole bed must be emptied and dealt with. With downward filtration, the top surface of the sand bed is visible, and shows at a glance whether cleaning is necessary ; and then the cleaning is simply done by lowering the water a little, and scraping off about half-an-inch of the sand. This small quantity of sand will be found to carry all the impurities, and it may be washed and replaced at once ; or, with a good thick bed, the top surface can be removed half a dozen times or more, and be put aside to replace at a future time, without affecting the efficacy of the filter.

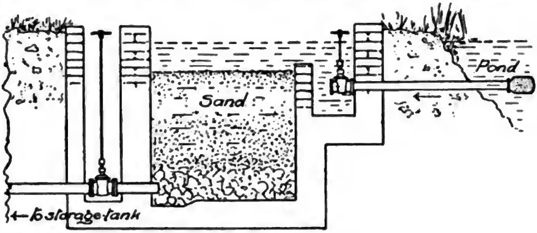

FIG. 131.

Fig. 131 shows a filter bed as might be made for a country residence which has to rely more or less on pond or lake water. The top layer of fine washed sand should be 30 in. thick, resting on 3 in. of pea gravel, this being on a layer of ½ in. and 1 in. gravel, resting on large stones. All must be carefully washed. The small tank or space where the pond water first enters is a settling bed for heavy impurities. This is not always provided, but as the extra cost is so small, it is a desirable adjunct to the filter bed.

Authorities differ very greatly as to the amount of work such a filter will do. Of course, much must depend on the state of the water, but in the writer's opinion a square yard of filter bed, such as this, should not be expected to deal with more than 350 to 450 gal. of water per day, this water being ordinary large pond or lake water to which cattle have no access. Thus a bed 4 ft. 6 in. long by 4 ft. broad will serve a fairly large house requiring 800 gal. of water per day from this one source. Filter beds of small size, as this would be considered, must be protected from frost. A hut is necessary, and this might be well lined with straw or with hair felt. The formation of ice, if of good thickness, could scarcely fail to injure the brickwork.

A most searching inquiry into the working efficiency of filters was conducted by Mr. G. Sims Woodhead, M.D., F.R.S.E. (Director of the Research Laboratories of the Board of Physicians and Surgeons), and Mr. G. E. Cartwright Wood, M.D., B.Sc. (Research Scholar of the British Medical Association), and this was embodied in a special report to the 'British Medical Journal.' To those who undertake the water supply to residences, or are in any way responsible in furnishing water for domestic or general consumption, it is of the highest importance that a full knowledge of filters and their capabilities be had, and, with this idea in view, a copy of the journal of the date given (or a reprint of the report can be had by itself) should be obtained by every one interested.

The question of filtration is an important one to the plumber, for it is not usual to find a source of water so pure, clear and free from doubtful qualities as to make filtration unnecessary; and even in the case of pure waters, or waters that have no suspicious origin, a filter is still a desirable adjunct to the water supply fittings. To arrest suspended matters and earthy impurities, recourse is commonly had to sand filtration, and for many waters this is sufficient, as only a fine strainer is needed. This is effected by a sand bed, laid on coarser material and large stones, and the water is allowed to percolate through it, leaving the impurities at top, and running off clear through a pipe below. At frequent periods the top surface of the sand is scraped off, and at longer periods the whole of the sand is submitted to a good washing. This is the filtration that river and lake water is generally subjected to before it enters the underground storage tank, whence it is pumped into the house cistern. For the drinking water, however, some more perfect filtering apparatus is usually resorted to.

The inquiry just referred to dealt with the filters as being intended to serve one or more of the following purposes:—

1. To remove all suspended material visible to the eye.
2. To remove organic matter in solution.
3. To aerate the water and render it sparkling, particularly in cases of rain water being used.
4. To remove micro-organisms from the water, especially those which cause the spread of disease.

Many of the filters proved successful in fulfilling the requirements of the purposes numbered 1, 2 and 3, but that of No. 4 proved a stumbling-block which but 3 succeeded in passing successfully, and few showed more than a very poor capability of dealing with. Of course, it is but a short time ago that micro-organisms and bacteria were practically unknown, and certainly in regard to their use in testing the efficacy of filters. The authors of this special inquiry, therefore, generously attribute the high testimonials given to some of the faulty filters by eminent analysts and medical men to the fact that they gave them years ago, when the present exact methods of testing with disease germs were next to impossible. Even now there may doubtless be many who would consider that a filter which removes suspended matter, also organic matter in solution, must be above suspicion almost as a matter of course; but it is conclusively proved that such a filter, perfect as it might be in those respects, is no safeguard whatever against the transmission of disease. Organic matter in solution may be sewage matter in quite a fluid state requiring an actual filtering substance to abstract it from water, yet the presence of this fluid matter is only indicative of contamination, and its removal does not necessarily mean the elimination of the real source of danger. This bears particularly heavy upon the makers who publish such statements as "The water which proceeds from this filter is a perfect guarantee against disease," and the like. The filter made by one very well known firm yielded a thousand more colonies of cholera bacillus on the second day than the test water itself contained, showing that the organisms had been stored up from the day before, and had probably undergone a growth and increase while in the filtering material. The same filter allowed half the bacillus of typhoid that was put in it to pass straight through at once. The report uses quite wrathful words in regard to this, as the filter was claimed to be "a safeguard against typhoid fever, cholera and blood poisoning." Remembering that the filters tested were quite new, and presumably in their best order, rather strong words cannot be wondered at.

A filter is used by every one as a preventative of illness which might be caused if the water was drunk in an unfiltered state. If the water is quite above suspicion, and not likely to be contaminated from any cause, then filtration would be unnecessary; but if, on the other hand, there is a risk of the water conveying disease germs, then the filter should be capable of arresting them, otherwise it is useless. When a filter is put into use, it is with the idea that otherwise illness (disease really) *may* be caused by the water, and although in many instances the risk is remote, yet when it does arise, the filter should be ever ready to deal with it successfully. Therefore, any filter that cannot be relied on, little or much, is something worse than useless, and on this point the inquiry has left no stone unturned. Such faults are dealt with as the possibility of unfiltered water passing direct through badly arranged fittings not properly understood by servants; materials used in fittings which would wear out, perish or decay; the difficulty or inability to clean the filtering material or the vessel holding it; the retention of filtered or unfiltered water in certain parts of the vessel, and so on. All filters were first tested with ordinary tap water (the filter being first carefully sterilised), also with colouring matters; afterwards, an organism specially suited as to size and character was passed in with the test water; then a test with the bacillus of cholera, and then with that of typhoid fever. The filters were always carefully sterilised between each test, and the care taken, from a scientific standpoint alone, is a monument of patient, clever work. There is another form of test that should be mentioned, this being with ordinary tap water, a filter having this water passed through it day after day for several days without sterilisation between. The idea was to see if the filtering material was favourable to an increase in the number of germs if the conditions were ordinarily suitable. In the majority of cases the filters gave very bad results in this, an average result reading thus: "Number of germs (colonies) per c.c. in the tap water, 40; number per c.c. passed through first day, 3; second day, 50; third day, 400; fourth day, innumerable. Thus on the second day more germs existed in the filtered water than in the unfiltered, and on the following days the water was in a vastly worse condition for the filtration it had undergone; but happily the germs of ordinary tap water are not of a dangerous kind. The final test to mention is that in which it was ascertained how long a filter having been infected with cholera bacillus was capable of infecting the water with cholera afterwards if fed daily with ordinary tap water. With one filter it was found that the cholera microbe could be traced and separated from the filtered water thirty-two days afterwards; the serious aspect of this is that the disease, as a rule, only attacks people when they are susceptible to it, and a man may perhaps take one or two doses without infection, but if he keeps on passing the germs into his body with the water he daily drinks, it may not be long before a susceptible moment occurs, and the disease will be with him from then.

The three filters that passed this rigid investigation successfully were the "Pasteur (Chamberland)," the "Berkefeld," and the "Aéri-Filtre-Mallié, Porcelaine d'Amiante." All of these consist of what are termed "candles" of unglazed porcelain material, candle-shaped tubes or cylinders, the water passing through the substance of the tube from the outside to the inside, issuing pure from the outlet of the latter. This prepared porcelain is a secret preparation in each case, and it must not be supposed that *any* such preparation will answer the same purpose. The success attained is due to the fineness of the water passages through the substance, consequently the filters are no more than highly-successful strainers. As the porcelain cylinders act as strainers it follows that the outer surface, which the unfiltered water first encounters, becomes coated with a slimy coating, and this must be regularly removed, otherwise the rate of filtration will be diminished. The directions of the vendors are very instructive in regard to this. "The germs and other impurities which are arrested form a deposit on the outer surface of the tube, and this must be cleaned off periodically. The cleaning is simply effected, and consists in brushing and rinsing off the deposit, which mostly comes away readily. Any deposit which sticks to the filter can be periodically destroyed by simply boiling, baking, or steaming the tube (sterilising it), or by using a cleaning substance as directed. The filters can be supplied with automatic brushers, if desired, so that that tube can be cleansed in position, without removal from its case, the residue being run off through a valve at the side."

The tap or pressure filters are frequently preferred to the larger kinds (which consist of a group or battery of candles), when possible to use them. The only reason for this is that when a number of candles are joined up to form a battery, there may be a certain amount of risk that the connections are not perfect, or the fittings may go wrong, in which case the success of the filter would be completely frustrated. The writer uses the tap filter for preference, as with an ordinary quality of water there is no occasion to filter all the water in the house. Water that is boiled in cooking vessels or in kettles, scarcely needs filtering (so far as removing living germs is concerned) as boiling is one of the surest simple means we have of sterilising water. The statements of filter-makers which led people to believe that boiling the water was a doubtful means of making the water safe, cannot be too strongly condemned.

Filters for Laboratory and Manufacturing Trade Purposes.—Text-books generally remark at the outset that it is very necessary to use a funnel the sides of which form an angle of 60°, this being the angle formed by the folded paper. Symes takes exception to this very exacting requirement. We do not get our straining bags or percolators made of such a shape, and that because our experience teaches us how much more suitable is a form in which the angle is decidedly more acute, the same volume of liquid in this latter form producing a longer column and consequently, a greater downward pressure. Then, as to the paper fitting the funnel we know quite well that all else being equal, the less perfectly it fits, the more rapidly filtration proceeds, so that, for any useful purpose, it is quite unnecessary to insist on this very orthodox shape. One has, say, a pint of fluid to filter, and for this purpose a funnel of about 8 oz. or 10 oz. capacity is taken. Symes would use one of the long French pattern, fold the filter in plaits, and before opening it out, place it fairly well down in its position in the funnel, or, if there were reasons for not plaiting the filter, then it should be folded, first in half and then the two outer portions, representing rather more than ⅓ each of the entire paper should be turned back so as to overlap each other slightly at the top, and not to form a very acute point. In either case, the paper, whilst being fairly well supported would have comparatively little surface adhesion, and but small resistance would be offered to the passage of the fluid in any part. Funnels of this shape, in much larger sizes, can be used with advantage, but it is then desirable to have them ribbed. The ribs of funnels (especially of large ones) to be of any real value, should be much deeper than they usually are, and should not run vertically, but spirally. A piece of muslin placed between the paper and funnel not only strengthens and supports the paper, but assists filtration by preventing adhesion ; a cone formed of coarse hair cloth is still better. For larger sizes, say of 4 to 8 pints, it is advantageous to dispense with the funnel altogether, and to use an inverted cone formed of linen or stout calico, the edges being fastened to a wooden hoop, which, resting on a deep earthenware pan, forms an efficient support for the paper, the liquid passing through with equal facility over the entire surface, a suitable cover placed over it excluding the air, and the process goes on under comparatively satisfactory conditions. A self-feeding arrangement can be fitted to this if it be so desired, in a very simple manner.

When, by exhausting the receiver, atmospheric pressure is brought to bear on the liquid in a funnel, then the latter should be of the *orthodox* shape, as with it air is less likely to pass ; but this requirement militates against the advantage that such a method would otherwise possess. The point of the filter should be supported by a cone of platinum, or zinc, or by a packing of tow or prepared wool.

English paper-makers do not appear to have devoted much attention to the production of filters in any variety, and for this reason we derive our supplies chiefly from the Continent. It is a well known fact that holding almost any of the common filters up before a strong light they are seen to be perforated more or less with minute pinholes, so that, when in use, it is only after these have become filled up that the whole of the solid matter is separated, and the liquid passes through bright. Each time a fresh portion of liquid is added the disturbance caused thereby is liable to remove some of the particles which are acting as a filling, and if this occurs, filtration again becomes imperfect. These filters, although very cheap, do not pay to use if time and convenience are taken into consideration. There is, however, considerable difference in the efficiency of the various kinds of filtering papers, even when free from this defect. The presence of animal matter, as in the grey filter, increases the strength, but diminishes its working capabilities, and the existence of mineral matters therein does the latter, but not the former. The papers specially prepared by Schleicher and Schüll are practically free from all extraneous matters, the pulp having been treated with hydrochloric and hydrofluoric acids, etc. They are an example of what can be accomplished in this respect, but at the same time they are too expensive for general pharmaceutical purposes, and, indeed, are only made in comparatively small sizes, suitable for analytical work. For operations requiring filters of 7 in. diameter (before folding), the Rhenish papers, No 595, are, in Symes' opinion, the most suitable ; for larger sizes, the French stout plaited or plain papers, taken in all their qualities, give the best results. The French also make a paper specially suitable for syrups, thick to support the weight, and yet sufficiently pervious to allow of fairly rapid filtration. Symes finds, however, in very large sizes, a double sheet of Rhenish paper in an inverted case of linen, as already described, answers even better.

Filter-paper which has been immersed in nitric acid (sp. gr. 1·42) and washed with water is remarkably toughened, the product being pervious to liquids, and quite different from parchment-paper made with sulphuric acid. Such paper can be washed and rubbed without damage, like a piece of linen. The paper contracts in size under the treatment, and the ash is diminished ; it undergoes a slight decrease in weight, and contains no nitrogen. Whereas a loop formed from a strip 25 mm. wide of ordinary Swedish paper gave way when weighted with 100–150 grm., a similar loop of toughened paper bore a weight of about 1·5 kilo. The toughened paper can be used with the vacuum pump in ordinary funnels without extra support, and fits sufficiently closely to prevent undue access of air, which is not the case with parchment-paper. An admirable way of preparing filters for the pump is to dip only the apex of the folded paper into nitric acid and then wash with water ; the weak part is thus effectually toughened.

Some fabrics, such as swansdown, close-textured twill calico, etc., filter as brightly as paper does, and may be used for that purpose as distinct from ordinary straining, provided the solid particles separate from the liquid in which they are suspended with ease, but when this is not the case, they are of much less value ; indeed, with paper as a medium, slimy deposits present considerable difficulty. Pepsin wine, prepared from the fresh, undried, pepsin, might be regarded as typical of this class of liquids, the tendency being to choke up the pores of the filter almost immediately the operation commences. In such cases, some kind of coarse straining material placed within the paper cone helps materially to obviate the difficulty. Hair cloth, and thin coarse flannel answer well for this purpose ; they operate by collecting on their rough projecting surfaces the larger proportion of the undissolved slimy matter, without becoming sufficiently choked up to materially impede the progress of the operation.

Succus taraxaci, as expressed from the root and mixed with spirit according to the B. P. instructions, is typical of a class containing a large quantity of starchy matter, and where subsidence in a closed vessel previous to filtration is of great service. The liquor from poppy capsules, in the process of preparing syrupus papaveris alb., furnishes us with an example of a liquid containing a large quantity of albuminous matter and mucilage which, when coagulated by spirit, has to be filtered off, and here again subsidence in a closed vessel helps the separation materially. The greater portion of the liquor can, after a time, be poured almost bright into the filter, and the remaining soft mass can, with care, be slowly pressed almost dry, the chief difficulty in the latter operation being to press sufficiently slowly to separate the liquid from the solid, and yet not to expose it to the air long enough to lose much spirit by evaporation, as in that case some of the solid portion would be again taken up in imperfect solution.

The 'Druggists' Circular' recommends chamois skin, free from thin places, cut of the desired size, washed in a weak solution of any alkali, to remove the grease, and rinsed thoroughly in cold water before using. Tinctures, elixirs, syrups, and even mucilages are filtered rapidly. A pint of the thickest syrup will run through in 4–5 minutes. By washing thoroughly after each time of using, it will last a long time.

For removing suspended particles from strong acids, spun glass, known as "glass wool," answers best, but this might be regarded as straining rather than filtration. With ordinary liquids, when there is but little insoluble matter, absorbent cotton not only strains, but by fairly tight packing, filters brightly. In cases where it is desired to save the deposit, and possibly to dry or incinerate it, asbestos paper can be recommended; the liquid passes through it slowly, but it is very strong, and it is indestructible by heat. Paper lint, as introduced from America some few years ago, answered well as a filtering medium, being both strong and absorbent.

So far we have considered filtration as conducted only in funnels or funnel-shaped arrangements, as the various forms in which atmospheric pressure is commonly employed are described in works which treat of such matters. They are chiefly those in which a long column of liquid is carried above the point of filtration, as in Proctor's arrangement, where exhaustion is obtained by means of a syringe underneath, or suction by means of a bent tube, as described by Schacht.

Symes considers that upward filtration is the direction from which we may expect the best results.

Some years ago, Warner invented an oil filter on this principle, consisting of 2 vessels in superposition, measuring altogether about 40 in. in height by 10 in. in diameter, and which is said to be capable of filtering a barrel of oil per day. This, of course, would depend on the nature of the oil and the temperature at which it is used.

Symes also devised a form of upward filter in one vessel only, and added to it a suction tube. It occupies comparatively little space, is simple in construction, efficient in action, and can be made by any tinman at little cost. It is shown in Fig. 132, and consists of a plain tin cylindrical vessel *a*, with a tap-hole *b* 1½ in. from the bottom; it is 22 in. high, and 8 in. in diameter. A tin tray *c*, 7 in. in diameter, with a vertical rim 1–1¼ in. deep, has a hole *d* in the rim, this and the hole near the bottom of the cylinder being fitted with a short female screw with the same pitch of thread. Over the tray, the filtering material *e* (flannel, calico, paper supported by muslin, or any other material that may be suited to the liquid to be operated on) is tied securely; it is then inverted and placed in the cylinder so that the holes *b d* are exactly opposite one another. A tap *f*, with a bend at a right angle, is screwed in so that it holds the two together, and assists a short leg *g* in supporting the tray in position. To

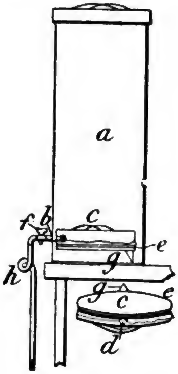

FIG. 132.

the end of the tap is attached a rubber tube turned on itself *h*, or a long glass tube of similar construction (in fact, take a large safety funnel deprived of the thistle head), which can be attached by a short piece of rubber tube. It will be obvious that any communication between the tap and the contents of the vessel must be made through the filtering medium which covers the inverted tray, and that any deposition which takes place must be on the bottom of the vessel itself, or on the opposite side of the tray, but not on the filtering surface, and herein lie the special advantages of the filter. The use of a long delivery tube is not new; it formed part of an oil filter patented by Britten, of Liverpool, some years before Schacht's application of it to his filter. Neither is upward filtration new, as already stated; but the combination of the two, and in this particular form, will probably commend itself to any one who will give it a trial. The dimensions given furnish a filter of about 3 gal. capacity, at a cost of some 10–12*s*. ('Pharm. Journ.')

A dealer in wares used by chemists informed Casamajor that he had many inquiries concerning asbestos for filtering liquids in chemical analysis. Some chemists complain that they cannot get clear solutions through asbestos, while others, who obtain clear solutions, find that their liquids filter altogether too slowly.

The method of making asbestos filters by pouring a thin paste of this material over a perforated platinum disc, was first proposed by Casamajor in 1875, and an admirable filter of this kind is made by Theo. Seitz.

The asbestos has the very great advantage of being insoluble in all ordinary liquids, and of not imparting any flavour or odour to the resultant filtrate. As employed by Seitz it may be fairly said that this method is almost perfect in its action, and can be applied to essences, perfumes and wines which can be suitably dealt with by no other system. It has this further advantage that the use of pumps does not force through the particles of asbestos or choke the filter.

Fig. 133 shows an improved method of supplying liquid to a funnel filter, invented by E. E. Robinson, and described in the 'Chemical News.' When large quantities of liquids, such as reagents, have to be filtered in the laboratory, it is often convenient to have some means by which the funnel filter may be kept filled. The handling of large bottles for the purpose of emptying the liquid into the filter is disagreeable and tiresome. By the arrangement shown, such labour is avoided and the liquid is at the same time silently but surely transferred to the filter.

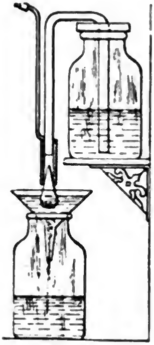

FIG. 133.

To the longer limb of the siphon is attached a short rubber tube. Operating vertically within the lower end of the tube is the narrow conical stem of a glass bulb float, in the bottom of which are 2 or 3 small lead shot or weights for the purpose of retaining the stem of the float in a vertical position.

As the liquid in the funnel filters out, the glass bulb descends, which in turn opens the bottom of the surrounding rubber pipe and permits the liquid in the siphon to flow out, falling over the bulb. If the liquid from the siphon flows faster than that through the filter, the bulb rises, and by its conical form wedges against the inner lower periphery of the rubber pipe, plugging the same, and stopping the flow therefrom. By this means the funnel is kept constantly supplied until all the liquid in the upper bottle has been siphoned out. An important advantage of this arrangement is that when once started it can be left without attention until the filtration is completed.

Fig. 134 shows a very simple apparatus for filtering water. Take a glass tube about 1 yd. long and of ¼-in. bore, and bend it twice at a right angle, as shown, so that the longer leg is about 6 times as long as the shorter. To the shorter leg is fastened by means of a perforated cork, a wider glass tube, about 4¾ in. long and ⅞ in. wide (inside); this tube is filled with absorbent cotton (freed from fat), a small piece of perfectly clean sponge being laid next to the cork, and a similar piece being used to close the other opening of the tube. In place of the narrow glass tube, a rubber tube may also be used. The apparatus is started like any other kind of siphon, and will be found to work well in all cases where the liquid is not too much loaded with suspended matters.

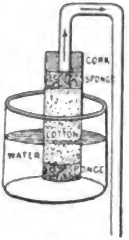

FIG. 134.

Dr. Ebermayer reports that he has found muslin, which is folded in shape of a filter, and placed below the latter to be an excellent promoter of rapid filtration. He had occasion to make use of such additional muslin filters, for the purpose of removing the paper-filters from the funnel, without tearing; and he thereby had occasion to notice this useful property of the additional muslin filter. ('New Remedies.')

It is known that certain precipitates such as sulphur, in emulsion pass through filter paper. Boisbaudran often employs a method which in many cases obviates this inconvenience and which, to his knowledge, has not yet been made public. Filter paper is boiled with *aqua regia* until the mass is fluidified; it is then poured into a large quantity of water, and the white precipitate formed is washed by decantation. To render the texture of a filter very compact, it is then filled with this material, previously stirred up in water, so as to form a very thin paste, and allowed to drain. The paper is thus covered with a layer, which obstruct its pores. Or a little of the same pasty matter may be mixed with the liquid to be filtered.

Eiselt recommends the use of sponge for filtering distilled water. The filtration goes on with great rapidity, and the product is clear as crystal. When filtered through paper, distilled water soon exhibits a "felty" sediment, which is never formed when filtered through sponge, so that the bottles scarcely need cleaning after several months' use. The apparatus that he employs consists of a bottle with an opening near the bottom from which descends a bent glass tube. This tube is about 6 in. long and 1–1½ in. in diameter; at each end is a perforated rubber stopper bearing a narrower glass tube. The wide tube contains one or two long strips of fine sponge that has been cleaned with dilute hydrochloric acid and then dried. The bottle to which this filter is attached must not be larger than the one placed beneath to catch the filtrate. The sponge, of course, must be cleaned every few months. ('Neuste Erfahrungen.')

Guncotton is scarcely acted upon by the most energetic chemical agents at ordinary temperatures, and may therefore be used as a filtering medium for solutions containing strong acids or alkalies.

G. F. Burton, of Springfield, Ohio, is the inventor and manufacturer of an appliance shown in Fig. 135, to be used in connection with an ordinary funnel or percolator, designed to prevent loss by evaporation and the escape of odours, and to exclude dust and flies. It will also serve as an air-tight cover to a macerating or infusion vessel. By the ordinary method of filtering and percolation one loses constantly by evaporation not only in alcohol, but often in the volatile portion of the drug, while to keep the filter or percolator supplied requires constant attention. If filled and left at night, in the morning the filtering paper will usually be dry and gummed, or the drug in the percolator be exposed to air. These difficulties are entirely overcome by this apparatus.

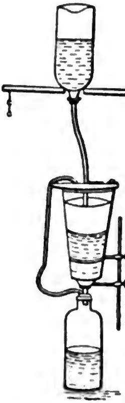

FIG. 135.

To use it, place the rubber stopper into the receiving bottle, and insert the funnel or percolator (previously packed). On this place the cover. Into a suitable discharge bottle containing the desired quantity of liquid, insert the cork with the rubber tube attached, closed by means of the pinch-cock. Secure this inverted, at a proper height, directly above the cover, and pass the rubber tube through it as far as it is desirable, to permit the liquid to rise in the funnel or percolator. Press on the rubber of the cover to secure it firmly to the edge of the funnel or percolator. There should be a slight bend in the supply pipe, otherwise it might draw the cover out of place ; if too much, there will be a free flow of liquid. Loosen the pinch-cock, when the liquid will flow until it reaches the end of the tube and close it. Then no more will run until the liquid is low enough in the funnel or percolator to admit air, when more will flow as before. Should the quantity of liquid be small, or for any other reason it is not desired to use the supply vessel, insert the stopper in place of the tube.

When the liquid begins to drop from the percolator, if it is desired to set it aside for a given length of time to macerate, instead of closing the lower orifice with a cork, the flow may be stopped by closing the air-tube by means of the pinch-cock. The funnel or percolator should not exceed 8½ in. in diameter. With this size, or a little smaller, a 7-in. filtering cock and No. 33 paper can be used. If it be desired to employ vessels the full size of the cover, to secure it perfectly tight, it may be necessary to weigh it down with sand, or by filling it with water.

Viscid liquids, such as are obtained in processes of artificial digestion, may be filtered, according to Fresenius, by the aid of finely picked asbestos fibre. Not only is the filtration of such fluids exceedingly slow, but the filtrate often passes turbid even through paper of the closest texture. To filter such a fluid, Fresenius advises to dilute with water, add some recently ignited asbestos, and shake the mixture vigorously. After about 12 hours the suspended matters will have subsided, leaving the supernatant liquid perfectly clear. This is to be siphoned off, and the residue to be washed once or twice by decantation, and then passed through a glass funnel the neck of which contains a pellet of asbestos. If the first part of the filtrate runs off cloudy, it is returned to the funnel until it passes clear.

A funnel for filtration in absence of air, is shown in Fig. 136. The funnel has a cylindrical rim 1–2 cm. high, covered with a lid provided in the centre with a neck. Into this fits a cork and bent glass tube. The funnel is fitted into a filter flask, which has a side tube. By connecting the tube of the funnel with that of the flask by a piece of rubber tubing, the exterior air is excluded. In case a particular gas is required, the funnel is then provided with a double-bored cork. Through one opening the gas is introduced, and it passed out by the other, a connection being made with the filter flask as before.

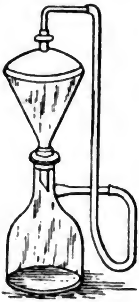

FIG. 136.

An apparatus for filtering and drying very oxidisable precipitates is shown in Fig. 137, and is constructed of glass with the exception of the cover C, which is of brass. The tube G, which is connected with the brass tube M by the cork F, is bent over and unites with a small flask containing the precipitate. This small flask has a cork with three holes, one for the tube G, a second for a glass funnel, and the third for a tube connecting with a gas generating apparatus. When all connections are found to be air-tight the tube C is connected with a water pump, and the cock E is opened; the precipitate is drawn over by lowering the tube G into the precipitate in the flask as soon as the apparatus is filled with the indifferent gas. The precipitate collects on the funnel A, and distilled water can be drawn over to wash the precipitate there, by pouring down the funnel in the small flask. By opening the tap D instead of E, the filtration can proceed more slowly, and this tap is also useful with very muddy precipitates. To dry the precipitate, the cork K is replaced by another without an opening, the glass tube G

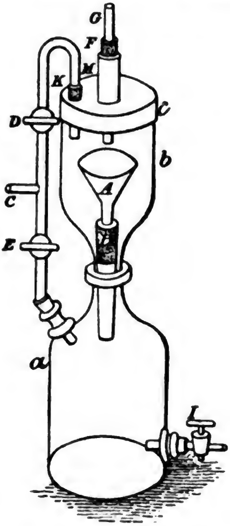

FIG. 137.

is fused off, and the upper part B of the apparatus is removed from the lower part A, and transferred afterwards to a drying oven.

A filter support, which is an improvement on the arrangement for rapid filtration described by Fessenden below, is shown in Figs. 138–140. It is made from platinum wire, copper wire, or any other suitable material, and bent in the shape shown in Fig. 140. A paper, folded as described by Fessenden, is pushed in between the wires, *a* and *b*, Fig. 138, which serves the same purpose as the glass rod, that is, to support the inner folds of the filter; whereas the ring, *f*, supports the outer folds, giving the whole an appearance of a paper formed with two compartments. This may now be placed in a glass funnel, or used alone simply by suspending it over the beaker as in Fig. 139, the liquid following the wire and dripping from the point, *g*. As a means of drying precipitates on the filter, it is far superior to the old way of placing the glass funnel with its filter in the drying oven, as the air has access to the paper from all sides, whereby it dries much more rapidly and thoroughly. For a 7½-in. filter, a support of $\frac{1}{32}$-in. platinum wire, with the ring, *f*, 2⅛ in. diameter, and the wires, *a* and *b* 3 in. long, gave excellent service. A glass rod bent as indicated by Fig. 140 works very well. ('Chemical News.')

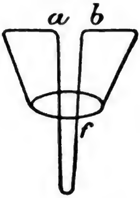

FIG. 138.

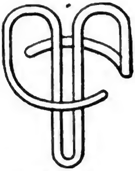

FIG. 139.

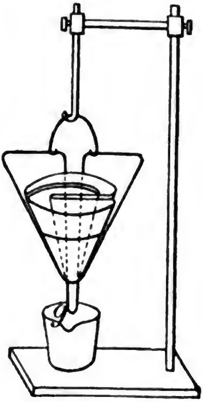

FIG. 140.

An automatic rapid filter is shown in Fig. 141, which indicates the manner of its operation from a common table, being entirely independent of the customary retort-stand. It uses very small circular filters 3¼ in. diameter, and yet filters many times faster than the largest heretofore used, doing its work thoroughly, and absolutely without attention, no matter how large the amount to be filtered. It is got ready quicker than the funnel, never breaks the filter-papers, and has no metal contacts. One of its strongest points is in filtering very small quantities as well as large. The former are run through in a moment's time without tedious dropping, as by the funnel.

The use of filter-pumps, as every chemist is aware, does not in a very great number of cases, facilitate filtration: first, because a dense layer of the precipitate forms next the paper. which continually requires to be removed, and second, if any considerable pressure is used particles of the precipitate will pass through. To increase the surface seems to be the better plan. Plaited filters partially effect this, but the precipitate cannot be easily detached from them, and they are troublesome to prepare. Ribbed funnels, while also an improvement, have only one side of the filter for use the other side being covered with three thicknesses of filter paper. The following method (Fig. 142) enables filtrations to be made very rapidly, and in such a manner that the precipitate can be readily removed: The filter paper is folded three times; folds Nos. 1 and 2 are toward the reader, No. 3 from him. The filter is then gathered (Fig. B), and a piece of glass rod, bent at a very acute angle, is inserted in the cleft of the filter (Figs. C and D), thus giving a filtration surface of nearly four times the usual one. The filtration being complete, the glass rod is grasped by the projecting ends and lifted from the funnel, bearing the filter upon it. One end of the filter paper is then bent down, and the precipitate is easily washed off (Fig. E). An improvement on this is to use, instead of the glass rod, a plate of glass (Fig. F) ribbed on both sides. This renders the filtration very rapid indeed, and if it were made by the manufacturers of chemical apparatus, would no doubt be used. (R. A. Fessenden.)

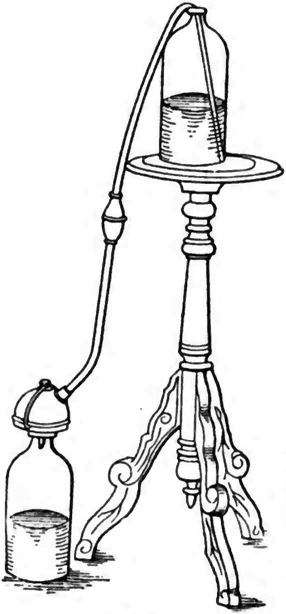

FIG. 141.

The production of a partial vacuum within the vessel receiving the filtrate has long been employed in chemical manipulations for the separation of dense precipitates, and also to save time in the ordinary processes of filtration required in the practice of chemical analysis. There is no reason why, in the absence of a centrifugal machine, the filtering of gelatine emulsions should not be hastened in a similar manner, considering at how small a cost an efficient filter-pump can be manufactured.

A good many vacuum pumps, worked by a flow of water, have from time to time been introduced to the notice of the public, but the majority of them are not completely satisfactory. Bunsen's is perhaps the best; but its production requires the aid of skilled workmanship, and the outfall tube must be at least 32 ft. in length. This altogether forbids its use except upon the upper floor of a building.

The pump to be described was designed by A. P. Smith some years ago.

The principle of its construction is based upon that of Giffard's injector. A cistern of water, such as is to be found in every house, is all that is needed for a water supply; but the greater the head of water, the greater the power of the pump. If the water can be laid on from the main supply, nothing further could be desired.

Although a good head of water—and, therefore, pressure—is desirable, it by no means follows that a large quantity of water is required. It is desirable to attach a screw pinch-cock on the rubber tube which connects the pump with the water supply, so as to govern the quantity flowing through—a condition easily acquired by a little observation and practice.

The greater the pressure of water, the greater the power of the pump, which is capable of lifting a column of mercury equal in height to that of the barometer at the time being *minus* the tension of aqueous vapour (the colder the water, therefore, the better). However, the pump will work very well, and lift 15 in. or more of mercury with a head of 10 feet.

The construction of the pump offers no difficulty to anyone who can bend a piece of glass tubing, draw out a jet, and bore a hole in a cork; this last is perhaps the most difficult of the three.

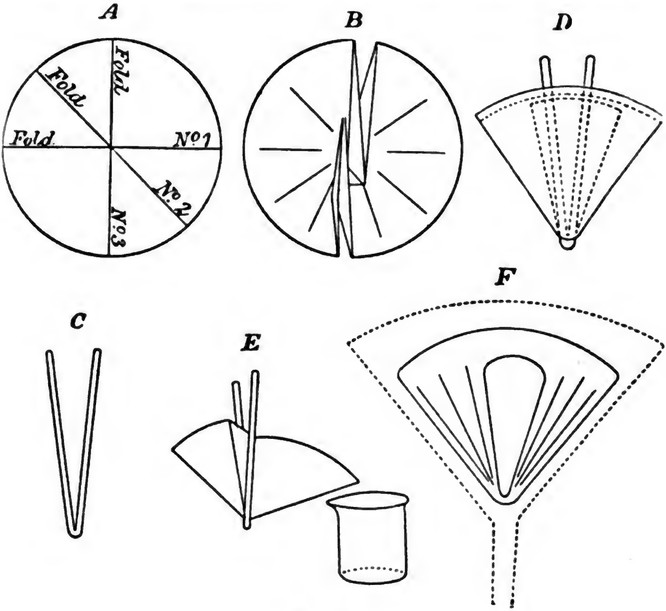

FIG. 142.

Procure a glass lamp chimney about 23 cm. in length, and some glass tubing of an internal diameter of about 6 mm. Fit two sound corks to the ends of the lamp chimney. Through the centre of the upper cork pass a glass jet with a short nozzle (Fig. 143). Through the lower cork pass another jet, having a long sloping nozzle. The diameter of the holes at the ends of the jets may be about 1½ or 2 mm. (The size really depends upon the water supply.) Care should be taken that the hole in the lower jet is not smaller than that of the upper jet; they ought to be the same size. These two jets are placed diametrically opposite each other, and nearly in contact, so that water flowing down may pass smoothly out of one into the other without striking the edge and spurting off into the chimney glass. A vacuum is produced at this point. This is really easy to accomplish, however difficult it may appear on paper. Adjust an exhaust tube through the upper cork, and, to make the whole affair like an instrument that is intended to work, and not like a model, mount it as in Fig. 144, where A is the pump, B C D the exhaust tube; but at B insert a three-way metal tube, and attach a barometer tube (same tubing as before), which dips into a vessel of mercury. The junctions with the metal tube may be made either by good corks or rubber tied on with wire (the glass tube must project inside the metal tube in any case), and all the junctions well covered with several coats of shellac varnish. The glass tubes may be fixed to a board in the manner shown in Fig. 145, by cutting a groove in a piece of cork, and screwing a strip of tin or brass over the whole.

The final adjustment of the jets can only be made while the water is flowing, and the barometer tube, or the exhaust tube, is dipping under mercury in order to ascertain when the pump is doing its best. When the proper position has been found (generally obtained by twisting the jet, as the point is sure not to be quite central), the corks may be covered with electrical cement, or several applications of shellac varnish.

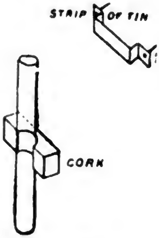

FIG. 145.

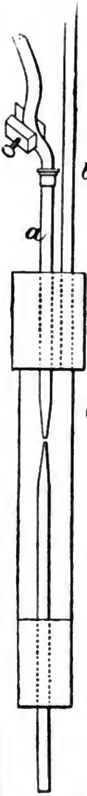

FIG. 143.

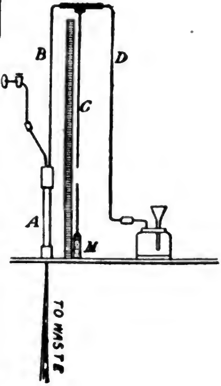

FIG. 144.

The filtering bottle requires no special description. Care must be taken to have a sound cork, and it is as well to soak it in melted paraffin to fill up the pores. The rubber which connects the bottle with the exhaust must be as thick as possible, and the ends of the glass tubes must be placed in contact, or the rubber will be flattened by the pressure of the atmosphere, and close the tube. A particular kind of rubber tubing is manufactured specially for such purposes as these, and cannot well be squeezed flat, as it has a diameter of 2 cm., and a bore of only 4 mm. However, ordinary black rubber tube will do very well for most purposes. ('Year-Book of Photography.')

Some precipitates are so exceedingly fine that the best filtering paper is incapable of retaining them. In such cases the difficulty may be overcome by stirring up with the liquid to be filtered a little finely-powdered French chalk (or paper pulp obtained by dissolving filtering paper in aqua regia and reprecipitating in water); this settling on the filter closes the pores of the paper still further, and prevents the passage of the precipitate. When filtering hot liquids which are very acid, or have a high specific gravity, much annoyance may be caused by the repeated breakage of the filtering paper. This can generally be prevented by supporting the apex of the filter on a strip of muslin laid across the funnel, or by using papers which have been steeped in 1·32 nitric acid for a few minutes, washed and dried, whereby the paper is greatly strengthened. For this purpose, also, an extra strong variety of filter paper has been introduced commercially, the peculiarity consisting in a network of linen threads interwoven with the substance of the paper during manufacture.

The ordinary funnel with sides at an angle of 60° is not adapted for very rapid filtration. The long French form, having a length about twice that of the widest diameter, yields much better results, and used in conjunction with a plaited filter paper gives the greatest rapidity of filtration which it is possible to obtain with the simple paper and funnel. Two forms of funnel, each the subject of a patent, have been introduced with the view of lessening the disadvantages of the ordinary 60° funnel. The first is furnished with straight projecting ribs on the interior, which to a great extent keep the paper from close contact with the sides, and this certainly aids filtration considerably. The second is of more recent introduction, and may be described as a funnel of the ordinary shape enclosing the body of a slightly smaller funnel perforated all over with small holes, and kept from contact with the outer funnel by 8 projecting ribs, the whole being made of earthenware in one piece. The space between the inner and outer bodies of the funnel is closed at the top, and a circular hole is provided in the latter, which may be closed airtight by a stopper. The patentees claim that this funnel may be used for a variety of purposes besides that of ordinary filtration, such as vacuum filtering, washing precipitates automatically, dialysis, etc., besides being a great improvement on the usual pattern. The following is the result of a comparative experiment with the above funnel. Time required to filter 4 pints of liquid — No. 1. Ordinary funnel, plain filter paper, 50 minutes, No. 2. Patent funnel, plain filter paper, 23 minutes. No. 3. Ordinary funnel, plaited filter paper, 8 minutes. The high price of the above funnel is its chief objection, otherwise it gives very good results.

The most perfect way perhaps of utilising a paper filter is that suggested by Dr. Symes. He makes a linen cone and attaches it at the top to a wooden ring resting on an earthen jar. The linen forms a support for the filter paper, and a suitable cover prevents evaporation.

There is one point to which great importance should be attached in the consideration of this subject, and that is that there is a certain material or combination of material best suited for the filtration of any given liquid, and much time may frequently be saved by carefully noting the filtering medium best adapted to each particular fluid. For instance, a strong infusion of poppy capsules precipitated by rectified spirit filters best through swansdown, liquid extract of bael through paper, a strong infusion of senna precipitated by rectified spirit through flannel, etc., and every liquid which presents any difficulty requires intelligent treatment according to its nature. One combination of filtering materials seems specially adapted to the filtration of syrups, flannel coated with raw paper pulp. Syrups pass through such a filter with comparative rapidity, and the filtrate is as brilliant as it is possible to obtain it even through paper of the finest texture. The bag should be made of very coarse flannel, and filled with a mixture of paper pulp and water which has previously been boiled until the pulp is quite disintegrated. As the water runs through the bag the pulp is left as a uniform layer on its interior.

There are several methods of assisting filtration by producing a vacuum in the receiving vessel, e.g. with the Bunsen pump; also an arrangement for producing a partial vacuum by connecting the receiving vessel with a bottle full of water placed at a height and communicating with a similar bottle at a lower level. The upper bottle acts as an aspirator, and when empty the positions of the bottles can be reversed, and the action rendered continuous. The pressure exerted by a column of liquid may be utilised in two ways, either to force the filtrate through in the usual direction, or to make it pass upward through the filtering medium. In the first case a reservoir is placed at a convenient height, from which proceeds a tube terminating in a ring or collar, to which the filtering bag is securely attached, the height of the reservoir determining the pressure on the contents of the bag. This method is very well suited for thick viscid liquids, which contain but little sediment, and which filter too slowly under ordinary atmospheric pressure. In the second case the filter is attached to the short limb of a siphon, so that the liquid passes in an upward direction through the filter, and herein lies its great advantage, viz. that the solid portion of the liquor, instead of settling on the filter and choking up its pores, tends to move away from it towards the bottom of the vessel.

The apparatus employed for centrifugal filtration consists of a shallow metal box supported horizontally on an axis, and capable of being revolved with great rapidity by means of suitable gearing. Inside is a similarly shaped but rather smaller box made of perforated metal or gauze, and fitting into the outer case so as to leave a space all round. The inner case is lined with flannel, forming a bag into which the liquid to be filtered is poured. On setting the machine in motion, the liquid is powerfully forced against the sides of the flannel bag; the clear portion then passes through into the annular space between the two cases, and leaves the sediment behind in the bag. A high speed is necessary to obtain good results.

Of the various methods just described none lends itself more readily to the filtration of thick viscous liquids (never ending sources of difficulty when considerable quantities are concerned) than that known as "upward" filtration. In this, advantage is taken of the pressure of the atmosphere by using a long column of liquid to suck the filtrate through. The apparatus usually employed for carrying out this process consists essentially of an inverted open box or cone, over the mouth of which the filtering medium is stretched, the cone being connected at its apex with the short limb of a siphon. The advantages of this arrangement are that by lengthening the siphon leg the rapidity of filtration may be increased to any reasonable extent, and by its position the filtering medium is prevented from becoming choked up with deposit, the sediment tending to move away from the filtering surface rather than to settle upon it. If a liquid containing a suspended precipitate be allowed to rest, a zone at the surface becomes clear in a comparatively short time, whilst that near the bottom still remains turbid. As a comparatively clear liquid filters much more quickly than a thick and muddy one, the position of the filtering cone (which must of necessity be placed near the bottom of the containing vessel) in an upward filtration arrangement is hardly correct, as the filtrate is drawn from a layer of liquid which is much more turbid than that at the surface. The correct position of the filtering cone is evidently at the surface of the liquid, so that only the clearest portion may have to pass through the filter, and full advantage be taken of the clarifying effect of subsidence.

In order to overcome the difficulties encountered, Bird devised the apparatus shown in Fig. 146 with a view of applying the principle of upward filtration, avoiding exposure to air at any stage of the process, and keeping the filtering medium in the most advantageous position, viz. at the surface of the liquid.

A is a stoneware jar, of about 2 gal. capacity, placed on a shelf at a height of 5–6 ft. above the vessel M. It is secured to a board C of suitable dimensions, perforated by a circular hole *q*. B is of wood, 3 in. wide, and also perforated by two holes *x* and *r*. C, A, and B are securely fastened together by a string or other suitable means. J is the filter proper, and consists of a circular box, closed at the top and open at the bottom, and about ¾ in. less in diameter than A. J is divided at the centre by a partition, which thus forms an air-tight chamber in the upper portion. The tube *t* passes through this chamber and communicates with the lower half of A, its upper end being connected to the glass tube H by rubber tubing. Over the open mouth of J is stretched the filtering medium, consisting of three layers, calico, paper, and flannel, the latter being on the outside. E is a bar of wood to which the glass tubes H and I are firmly attached. J, H, I, E forming a rigid system, partially counterbalanced at its centre of gravity by the weight F through the cord and pulley G, the whole being capable of

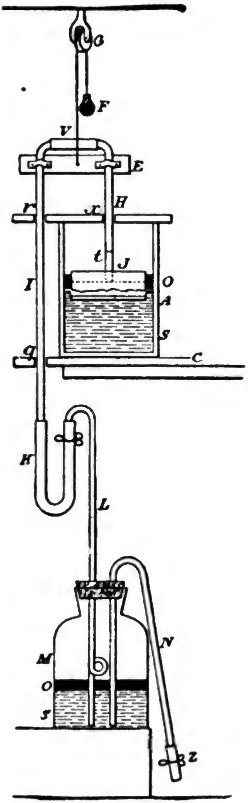

FIG. 146.

free motion up and down, so that J rises and falls with the liquid in the interior of A. The tubes H and I work through the holes x, r, and q, which serve as guides. The weight F should be such that when A contains no liquid J just descends freely to the bottom of the jar. K is a piece of rubber tubing connecting I and L, so as to allow of the free motion of I. L is a glass tube passing into the bottle M and twisted once as shown, near the bottom. A siphon and pinch-cock N, Z, are required to draw off the filtrate from M.

If it is desired to start filtration, A is filled with liquid, when, by the buoyant action of the air chamber in J, aided by the weight F, the filter rises to the surface. A cork is inserted in the bottom of L, and the end of the rubber tube V is removed from I; through V and I, I K L and H J are filled with liquid (preferably bright). The connection at V is again made and secured, and a layer of colourless heavy petroleum oil about ¼ in. deep is poured on two surfaces O of the liquids in A and M. As soon as the end of it is enclosed, filtration commences and goes on continuously. The oil is of course unnecessary in the case of liquids which do not suffer by exposure to air. Glass jars, furnished with stop-cocks at the bottom, may be substituted for the vessels A and M with considerable gain in convenience. All joints must be bound with waxed thread or wire, and thick rubber tubing used, to avoid collapse of its walls and consequent stoppage of the flow; the filter J should also be well varnished with shellac dissolved in methylated spirit. The construction of this filter demands but a small amount of mechanical skill; it works continuously, requires but little attention, and perfectly protects the liquid passing through it from the action of the atmosphere at any stage of the operation.

Filters for Liquids demanding Special Conditions.—There are some few liquids or solutions that cannot be suitably filtered in an apparatus such as may be employed for water, though Seitz's asbestos filters may be strongly recommended for the purpose. They are chiefly fluids of an oily, gelatinous, or syrupy character.

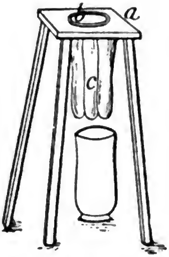

FIG. 147.

Gelatinous Fluids.—A simple and rapid method of filtering gelatinous mixtures will doubtless be acceptable to many photographers. The plans usually recommended are, the use of a funnel plugged with tow or cotton-wool, or a piece of cambric or other material spread over a jar, on which the solution is poured and allowed to percolate through. These plans are altogether unsuitable where large quantities of liquid have to be filtered, and even for small quantities the process is slow. The gelatine has to be kept warm till the operation is complete, and a rather open material must be employed, or the solution will only fall through drop by drop. The plan here described will be found very expeditious, there is no waste, a filtering material of the closest texture may be used, and the warm mixture is filtered before it has time to thicken by cooling. It has been used successfully for filtering gelatino-bromide emulsions and the gelatinous mixtures employed in the preparation of carbon tissue. The arrangement referred to is shown in Fig. 147: a is a wooden stand 18 in. high, having a hole in the top 4 in.

in diameter; *b* is a ring made of bent cane or whalebone, slightly larger than the hole in the stand. The filtering material, which must be of the closest texture, should be cut in a circular form about 22 in. in diameter; when secured to the ring with stout thread it forms a bag *c*, the ring *b* preventing it from falling through the opening in the stand.

To use the apparatus, the operator pours sufficient of the mixture into the bag to half fill it; he then seizes the bag, above the liquid, with his fingers, and presses the filtrate through into a receptacle placed below to receive it. Further portions of the mixture are poured in till the whole quantity has been filtered. With the measurements given above, quantities varying from 4 to 40 oz. may be readily operated upon. ('Photog. News.')

Liquids Affected by Air.—Fig. 148 shows a rapid-acting filter by Vollmar, for liquids liable to change by exposure to the air. The filter is hermetically closed while working. It is lined inside with filtering paper, and the filtration takes place so that the turbid liquid enters the filter below, passes through the paper, and is discharged clear at the top, where a pipe conveys it into a receptacle. This arrangement is of special service for filtering wines or other delicate liquids which should not be long exposed to air. A siphon inserted into the cask containing the turbid liquid, which stands on an elevated place, conveys the liquid to the filter, and thence it flows into the new receptacle. If the liquid is very sensitive to air, and a layer of oil cannot affect its flavour, some pure olive-oil may be poured into each cask, and the delivery tube leading from the filter be pushed down to the bottom of the receiving cask. In this way the liquid is absolutely protected from contact with air.

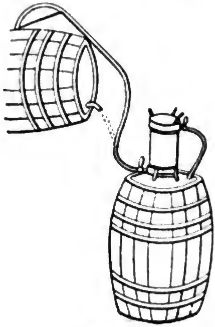

FIG. 148.

Lime Muds from Soda Causticisers. These are generally drained in a filter consisting of a half boiler, cut longitudinally, loosely paved with bricks, which are covered with layers of coke to a depth of 9 in. or so; the bottom layer is composed of good-sized lumps, the top of small pieces, surmounted by a covering of coarse sand or cinders. Over the filter-bed are laid perforated iron plates or grids, upon which the mud is placed.

Syrups.—The filtration of syrups and saccharine fluids is largely performed in what are familiarly known as "bag" or "Taylor" filters. The construction and arrangement of these are shown in Figs. 149, 150. The filter consists of a wrought-iron case *a*, with openings at *b*, and an internal flange at top to carry a cast-iron box *c*, having holes in the bottom, for the reception of gun-metal bells *d*, to which are attached cotton-twill filter-bags *e*. Fig. 150 shows an enlarged section of the gun-metal bell *d*. The bags *e* fastened to these bells are 3–6 ft. in circumference and 6–10 ft. long, woven without a seam. They are crumpled up inside "sheaths" of strong open webbing, about 18 in. in circumference, which restrict their expansion. They are arranged in series of 100 or more.

In sugar refineries use is largely made of animal charcoal, packed in huge cylinders.

Oils.—The filtration of oils may be

effected in a very great variety of ways, either with or without the assistance of artificial pressure derived from (*a*) a "head" of the liquor to be filtered, (*b*) one of the many forms of filter-press in use, or (*c*) atmospheric pressure by the production of a vacuum *under* the filter-bed. For example, olive-oil is mostly subjected to no process of purification beyond what is attained by allowing it to deposit impurities and repeatedly decanting. But, for the best qualities, further purification is necessary not only to secure limpidity, but a capacity for lengthened preservation by eliminating the water, mucilage, and parenchymatous matters. Various devices are employed in different localities, one and all being filters. In France, the

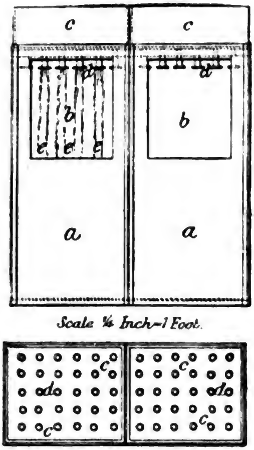

FIG. 149.

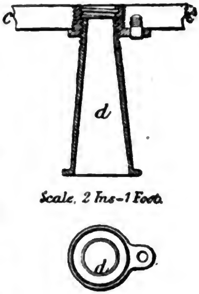

FIG. 150.

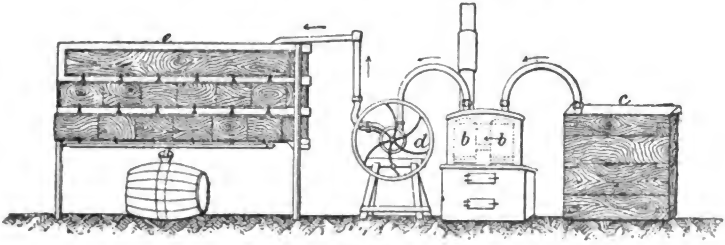

FIG. 151.

oil to be purified is received into perforated boxes carpeted with carded cotton (wadding); elsewhere, cotton tissue interposed between beds of granular and washed animal charcoal form the filter; a bed of dry moss, on the "Grouvelle et Jaunez" system; layers of sand, gypsum, and coke; alternate beds of sand and vegetable charcoal, according to Denis de Montfort's plan; carbonised schist and peat, by Cossus' method; clay heated to 200° (? F.), as proposed by Wright; by introducing china-clay and allowing to stand at a moderate temperature, then filtering through cotton, as adopted by A. Pizarri. Perhaps the best mode is that of Isnardi. This apparatus, Fig. 151, consists of a boiler full of water, serving as a water bath for 2 turned-iron cylinders *b*, receiving the oil from the reservoir *c*, a suction- and force-pump *d*, and a filter *e*, containing perforated trays whose holes are filled with wadding. This apparatus enables the oil to be filtered without coming into contact with the air, and at an elevated temperature which can be regularly maintained. Coco-nut oil is another example of purification by simple subsidence and filtration.

Percolation.—This is a kind of filtration, commonly called "by displacement," employed for extracting the essence from roots, herbs, seeds, barks, etc. It is effected in the following manner: It is first necessary that the articles to be acted upon should be ground in a drug mill to the condition of a coarse powder; then moisten the mass thoroughly with alcohol, allowing it to "macerate" for 12 hours in a vessel well covered. Next is required a hollow instrument of cylindrical form, having one end shaped like a funnel, so that it can be inserted in the neck of a glass bottle, and having inside, near the lower end, a partition pierced with numerous small holes, like the strainer of a French coffee-pot, which is a simple coffee percolator; in the absence of such a partition, soft cotton, or any insoluble substance, may be substituted, and being placed in the inside at the lower end of the instrument, will answer as well as the strainer. This instrument is called a percolator. Boullay's filter or percolator is usually employed. Macerate the ingredients to be acted upon, for the time named—introduce them into the percolator, and slightly press them upon the partition. Any portion of the liquid used in the maceration, not absorbed by the powder, should be poured upon the mass in the instrument, and allowed to percolate. Now gradually pour into the percolator sufficient of the alcohol, or other liquid to be filtered, to drive before it, or "displace," the liquid contained in the mass; the portion introduced must in like manner be "displaced" by another portion; and so on, till the required quantity of filtered liquor is obtained. This extract is called a tincture. In case the liquor which first passes through should be thick and turbid, again introduce it into the instrument, being very careful not to have the powder too coarse or loosely pressed, or it will permit the liquid to pass too quickly; and on the other hand, it should not be too fine or compact, or it may offer an unnecessary resistance. Should the liquor flow too rapidly, return it to the instrument, and close it beneath for a time, and thus permit the finer parts of the powder to subside, and cause a slower percolation.

The first portion of liquid obtained by the method of displacement is always in a state of high concentration. In general, it is a simple solution of the soluble ingredients of the crude drug in the fluid employed. But sometimes the solvent, if compound, is resolved into its compound parts, and the fluid which passes through it at any given time is only *one* of these, holding in solution only the most soluble parts of the drug.

Thus, if diluted alcohol be poured over powder of myrrh, in the cylinder of the percolator, the fluid which first drops into the receiver is a solution of an oily consistence chiefly composed of resin and volatile oil dissolved in alcohol. In like manner when the powder of gall-nuts is treated in the same way by hydrated sulphuric ether, two layers of fluid are obtained, one of which is a highly concentrated solution of tannin in the water of the ether, and the other a weak solution of the same principle in pure ether. In all cases, therefore, in which it is not otherwise directed, it is absolutely necessary to agitate the several portions of the liquid obtained by percolation together, in order to ensure a product of uniform strength or activity.

To illustrate the operation of displacement, and describe an excellent percolator for making perfume tinctures, we will suppose that benzoin is under treatment. The apparatus, made wholly of glass, having been arranged, as shown in Fig. 152, and a plug of raw cotton dropped loosely at *a*, the benzoin in coarse powder is then poured into the portion *b* until it reaches the line *c*. Alcohol (95 per cent.) is next added, until it rises to the line *d*. As soon as the first portion sinks into the benzoin, a fresh addition must be made; and thus the succeeding relays go on displacing those which preceded them without mingling with them. Each stratum becomes more and more charged with soluble matter as it descends; and when it reaches the bottom of the mass, under the pressure of the superincumbent liquor, it runs out saturated. When, by successive additions of fresh alcohol, the benzoin under treatment has become exhausted, the liquid passes through the mass, and falls into the receiver *e*, as tasteless and colourless as when first poured in. This indicates the completion of the process.

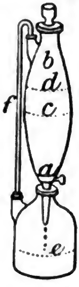

FIG. 152.

As atmospheric pressure is an important element in the operation, it will not answer to shut it off by closing the top of the displacer, without making some compensation; and, therefore, a communication between the upper and lower vessels is established by means of a latent-tube arrangement *f*. In this manner the apparatus is kept close, and the evaporation of alcohol prevented, while the pressure produced is distributed throughout the apparatus, and rendered uniform. As the runnings are clear, filtration is rarely necessary. The quantity of alcohol thus consumed need not be more than sufficient to exhaust the material; and the resulting tincture must therefore be diluted to the proper strength. For perfumes, deodorised alcohol must always be used.

The method of displacement has the advantage of expedition, economy, and yielding products possessing uniformity of strength; but it requires considerable experience to adapt it to all substances. The art rests in properly packing the ingredients in the cylinder, some substances requiring considerable pressure to be used, while others, when even lightly packed, scarcely permit the fluid to pass through them. An excellent plan, applicable to all substances, but especially those of a glutinous or mucilaginous nature, is to mix the powder with an equal bulk of well-washed sand before rubbing it up with the menstruum. The coarseness of the powder must also be attended to. Substances that readily become soft and pappy when wetted by the menstruum, should not be used so fine as those that are more woody and fibrous. The method of displacement answers well for the preparation of all tinctures that are not of a resinous nature, and for most infusions of woody and fibrous substances, as roots, woods, barks, leaves, seeds, insects, etc. It is especially adapted for the preparation of concentrated infusions and essences, as they may thus be obtained of any required strength, without loss, or requiring concentration by heat, which is so destructive to their virtues.

When ordinary tinctures are made in large quantities, displacement is never likely to supersede maceration on account of any practical advantages it may possess. If the prescribed directions be duly attended to, the process of maceration is unexceptionable. The process is more simple than the other; the mode of operating more uniform; it is, in fact, always the same; it requires less of skill and dexterity in conducting it; it requires less constant attention during its progress, which, in operating on large quantities, is a consideration; and finally, the apparatus required is less complicated. When, however, only small quantities are to be made at a time, and kept in stock, the adoption of the process of displacement will often be found convenient and advantageous. It offers the means of making a tincture in 2 or 3 hours, which, by the other process, would require as many weeks.

The preceding remarks are mainly gathered from Cooley's Cyclopædia. More recently the subject has received great attention from J. U. Lloyd, of Cincinnati, Ohio, and the results of his observations are thus recorded in the Proceedings of the American Pharmaceutical Association :—

One of the most frequent operations to be performed by the pharmacist is to separate from the crude materials, offered principally by the vegetable kingdom, active principles from others inert or not desirable. This object is reached by bringing the same into the liquid state by solution, with the aid of a proper solvent (menstruum). Thus we have the process of maceration and percolation, the latter being a modification of the former, calling in the aid of gravitation. To arrive at a proper understanding of the laws which govern the solution of substances, that is, the transfer of a solid into the liquid state through the aid of solvents, we should consider first the greatest agent in percolation—the attraction of gravitation. This unknown force impels all terrestrial bodies toward a common centre, the centre of the earth.

If we arrest the fall of a solid and pour upon it a liquid, that liquid will flow over the solid, excepting a small amount held by adhesion, and will fall from the lower surface towards the earth. If that solid be impenetrable, and insoluble in the liquid, it will remain intact; if soluble, it will gradually assume the liquid state and disappear. If the solid be porous the liquid will enter. This is due to absorption—a molecular force, which is working independent of the attraction of gravitation, and overcoming it to a limited degree, thereby exercising a great influence over the process of solution, beneficial inasmuch as it ensures a closer and more continued contact between the solvent and the solid. Thus, if a certain amount of liquid be slowly poured upon the porous body, we shall find that attraction of gravitation will fail to detach the liquid from the lower side; it does not flow over the outside, but enters, is absorbed, and held within its substance. The attraction of gravitation still exerts itself, for the actual weight of the mass is the sum of the separate weights of the 2 bodies. Without further examination we might suppose the materials at rest; such, however, is not the case. There are disturbing elements which produce constant motion; thus, an alteration of temperature will excite a change in the relative position of the molecules of the liquid, and temperature constantly changes. But besides the motions of the molecules, caused by the constantly varying changes of temperature, there is osmosis, an attraction that induces currents of liquid through cellular tissue. Gravity, however, overcomes at first all of these various contrary influences—among which we may class diffusion—and is ever tending to draw the liquid most heavily charged with soluble matters downward through the lighter, and thus there seems to be no rest, but, on the contrary, continual change.

The influences mentioned exert themselves whether the solid be large or small, whether a single particle of dust in a quantity of liquid or an innumerable number placed in a mass and covered with liquid. Let us turn our attention to solution. Throwing aside all theories as to the why and wherefore of the change of state from solid to fluid, we must accept the fact that below the melting temperature certain solids will, to a fixed extent, assume the form of liquids if in contact with particular fluids. The conditions necessary to effect and promote this change are: surface exposed to the dissolving medium, circulation of the liquid, temperature and time of contact between the surfaces of solid and the liquid. In regard to the first of these conditions, it is invariably found that the rapidity of solution increases with the area of the surface exposed; thus, for an example, if a cubic crystal of potassium bromide, or any other substance, 1 in. in dimension, be surrounded with water, the surface in contact with the water will be 6 sq. in. If the crystal be bisected by a plane parallel to any 2 of its sides, the amount of the material remains the same, but its surface has been increased 2 sq. in. Let each half now be divided into 4 equal parts, and there will be a total of 12 sq. in. of surface, exactly twice the amount of the original cube. Division can be theoretically, and in the above instance according to mathematical laws, continued to the extent of our imagination, and each cube divided into 8 will double the amount of the surface. But in practice we meet with obstacles of various nature which soon interpose insurmountable limits to accurate divisions, making our further efforts in that direction impracticable, and the desired increase of surface is most readily effected by pulverising the solid, thus obtaining irregular surfaces.

In considering the rest of the conditions upon which solution depends we next observe the action of currents.

Thus immerse a cubical crystal of potassium bromide 1 in. in dimension in water, and its 6 sq. in. of surface will be in contact with 6 sq. in. of water surface; immediately the 2 surfaces act together, resulting in the disintegration of the surface of the salt, which assumes the liquid form and blends with the surface of the water in the most intimate manner. This change takes place to a fixed extent, dependent upon the temperature and the saturation of the solvent. If the crystal be at the bottom of a vessel of water, it commences most rapidly to diminish in size from the top until finally it disappears. In observing closely the process we notice streams of liquid circulating about the crystal. These currents, colourless and transparent like the surrounding medium, are clearly visible from the fact that they refract the rays of light differently, an optical result caused by the portions of liquids of different densities, for the particles which form the surfaces of the salt unite with those of the water surface, resulting in a compound that has a greater specific gravity than pure water, consequently, as soon as united, this fluid flows over the crystal and down its sides in obedience to the laws of gravitation. It strikes upon the bottom of the vessel and, in response to the law that fluids of different densities seek their own level, spreads out, and in doing so displaces its bulk of water, which rises and replaces the solution about the crystal, and thus continuous currents flow over and down the sides of the crystal, and fresher menstruum is constantly taking the place of that more saturated. We might liken the foregoing to a surface of liquid resolving against a solid, each movement of which wears away the solid and decreases the wearing force of the liquid. At last, if the amount of water be sufficient, the crystal will have disappeared, and at the bottom of the vessel will be found a dense solution at rest surmounted by a lighter one. Again cautiously introduce a crystal of the same salt and the aforenamed phenomenon will take place, though in a less marked degree. The circulation of the medium becomes gradually less and less distinct, and finally, if the salt be in excess, disappears. There remains now a remnant of potassium bromide surrounded by a dense solution, while overlying we find almost pure water. In obedience to what is generally considered another force, which, it is thought, produces the diffusion of liquids, the solution and overlying water continually but slowly intermingle. At last, they are homogeneous, preceding which, however, the remnant of crystal at the bottom of the vessel will have disappeared. The foregoing exemplifies the changes which take place, under like conditions, when the crystal is broken excepting that the increased amount of surface contact, before considered, hastens the operation. Thus we find that nature's laws constantly produce circulation while solution is progressing. Arguing therefrom we should be able to hasten the operation at certain stages, and assist nature by frequently stirring the entire liquid, thus mixing the solutions. Recognising the theoretical value of circulation and extent of surface, when we wish to dissolve substances we should powder them, and stir the liquids at short intervals.

Temperature is most important. With a few exceptions substances dissolve to a greater extent in warm than in cold liquids, and even though the material be scarcely more soluble in the hot menstruum it dissolves more rapidly. This results from the fact that liquids while rapidly changing temperature are in a more rapid state of circulation, and heat also decreases the cohesive attraction of solids, their molecules being more easily detached from the mass, and therefore more readily unite with those of the liquid. Few operators have failed to notice the benefit of a warm room when dissolving substances. Careful manufacturers cannot allow the process of percolation to be conducted at winter temperature, even though so doing results in great saving of alcohol by lessening evaporation. Time is a consideration of importance. An appreciable amount of contact must be allowed between solvent and solid. That solutions require time for action is a principle well recognised and scarcely necessary to mention.

Having now briefly noticed the influences which govern solution, let us consider the relation between maceration and percolation, as these processes are called, bearing in mind the fact that the direct object is the solution of certain substances. Place 2 oz. of powdered buchu in a vessel and saturate thoroughly with alcohol. Then fit closely on the powder a sheet of blotting paper, and add alcohol so that the entire amount used is 16 fl. oz.; then very carefully remove the paper so as not to disturb the powder. Now we shall have the principles of solution exemplified exactly as in the previous example, excepting instead of one crystal we have a number of very small fragments, and instead of a perfectly soluble material the substance is only partially soluble, and in addition to other forces we have capillary attraction.

Solutions of different densities quickly form throughout the interstices of the powder. These solutions are in constant motion. They are subject to the forces before mentioned, but by the predominating influence of gravitation and constant tendency of the heaviest solutions is downward, and the densest part of the solution constantly seeks the lowest point. Thus we have new surfaces presented between solvent and material, attended in the first place with a handing downward of the dissolved matter. Apparently, the liquid and the powder are at rest; actually, there is constant motion, and so long as the act of solution progresses the circulation of the menstruum continues. However, these forces cannot extend their influence above the surface of the powder. It may be suggested here that diffusion can effect the mixture. Consequently the liquid within the interstices of the powder may be strongly saturated with dissolved matters, while that just overlying is scarcely contaminated, and that near the surface of the vessel is for some time perfectly pure. Assuming now that we desire to transfer the dissolved matter equally to all portions of the liquid, we most easily accomplish the object by stirring the contents of the vessel until the menstruum above and the solution within are thoroughly incorporated. When allowed to rest, solution as before proceeds; and when we again stir the contents of the vessel, we transfer a certain proportion of dissolved matter to the overlying fluid. Each operation depletes the powder to an extent of soluble matters and tends to produce an equilibrium between menstruum and material. The process of solution becomes gradually less active, and at last ceases to any perceptible degree, at which point we find the liquid above the powder and the liquid within identical. However long we may allow them to remain together, and however violently they may be agitated, we cannot further deplete the powder without increase of temperature. This is maceration, and thus it is we cannot by maceration represent the powder operated upon, for when the supernatant liquid is filtered from the powder, soluble matters in proportion to the liquid within the powder must remain with it. As the liquid obtained is to the entire menstruum, so must the material in the liquid obtained be to the material dissolved by the entire menstruum.

Other inconveniences attend the practical application of this mode of extracting the soluble substances from our plants. A very serious objection is the time required—generally 2 weeks. This, perhaps, more than any other cause, interested pharmacists in a general endeavour to improve. Another desideratum was an increase of strength in the product. We will consider briefly a slight modification of this process of maceration. Let us carefully moisten 2 oz. of powdered buchu with alcohol, press firmly into a container, and cover with the same menstruum. The operation of solution will be repeated exactly as in the other example. At length the liquid within the powder, and that in the cavities between its particles will be identical. When this state arrives, we remove the material to a press and obtain all the liquid possible by pressure.

The residual material is again finely comminuted, macerated with fresh alcohol, and again submitted to pressure; the operation being repeated as many times as is considered necessary. It at first strikes us with reference to this process, that as we constantly remove saturated liquid from the powder, and substitute perfectly pure in its place, we must soon perfectly deplete the powder. But by any ordinary means we cannot remove all the liquid, and certainly that held within the powder must contain its full proportion of dissolved matters. Therefore assuming that it required 4 oz. of alcohol, and the liquid within the powder and that between the particles had become identical in composition, and 3 oz. liquid were obtained (a liberal allowance), ¼ of the strength must remain in the residuum; consequently the 3 fl. oz. obtained, containing ¾ of the extractive matter, represent 1½ oz. of buchu, or ½ oz. of powder to each fl. oz., and each of the following operations dilutes this. At each successive step the powder, preceding and following maceration and expression, contains the same amount of liquid, and for every 4 oz. of alcohol applied, 4 oz. of solution are obtained, excepting loss by evaporation, which will not be considered here. Decrease in quantity of powder by having a portion of its extractive matter removed by each maceration is also disregarded. The second expressed liquid we find represents but $\frac{4}{5}$ of the extractive matters remaining in the powder, that is $\frac{4}{5}$ of $\frac{1}{4}$, which is $\frac{1}{5}$ of the whole, or original quantity, which, added to the $\frac{3}{4}$ obtained by the first operation, makes the sum of $\frac{19}{20}$ contained in 7 fl. oz. of solution, a little less than $\frac{3}{20}$ to the fl. oz. The first operation produced $\frac{5}{20}$ to the fl. oz., therefore there is a reduction of a little more than $\frac{2}{20}$ to the fl. oz. by the second maceration. Theoretically this procedure may be carried to infinity before entirely exhausting the material. Practically, the exhaustion will not be as thorough as our example represents. From considerations yet to be named, the writer believes it is impossible to obtain an expressed liquid containing substances of the plant capable of being dissolved by the menstruum, in the great proportion between successive percolates indicated by this ideal example. It is invariably found that a tenth maceration will produce an appreciable amount of extractive matter, and when we come to study the constituents of plants and their relations to menstruum, it will be doubtless accepted that such must be the case. As the matter stands, those that favour this process cannot well object to the argument and table, inasmuch as it admits of the greatest possible depletion of the powder. Others may, perhaps, with good cause, argue that theoretical proportion of soluble matters extracted will be less than the above on the assumption that the menstruum and the inert portion of the powder are alike impregnated with soluble matter and that the actual proportion should be between menstruum squeezed from the mixture and entire residuum. Another trouble attending this process in practice is the necessity of finely dividing or pulverising each residue before remaceration, an operation tedious and difficult to accomplish in the majority of cases, especially when large amounts of material are worked. Lloyd never succeeded to his satisfaction in a general way, without passing the residuum through a sieve after each expression, an operation not easily accomplished, especially with substances which agglutinate, although in certain instances the process is preferable to any other. Our aim we understand to be the transference of soluble matter from material to liquid, if possible representing a grain of the material with a minim of the solution. This latter result we have not yet accomplished and cannot by either process of maceration examined. In the first case we operate directly against the laws of nature. We are continually transferring a dense solution upward. In the latter example we neglect to take advantage of nature's greatest force. We use manual labour to accomplish, in the way of separating the liquid, what gravitation will do for us to any extent, and better in every particular. Now let us modify the operation by repeating the experiment of maceration exactly as heretofore, but in a vessel with a layer of cotton at the bottom, and an exit below, care being taken to avoid stirring the powder. After the usual maceration, cautiously open the exit and allow the liquid to escape at the very bottom of the powder. As a consequence we obtain the densest liquid at first, and substitute in its stead at the surface perfectly fresh menstruum, with the advantage that the liquid extracted has always passed through the entire material. Thus we find the product is constantly decreasing in colour and flavour and the powder is continually submitted to the action of a moving menstruum.

We use no manual labour after preparing the apparatus, and have no pressed residue to pulverise. We simply connect maceration as before examined to one of nature's most familiar laws, and in this latter experiment have an exemplification of the process which Prof. Procter recommended for the preparation of fluid extracts and tinctures. It is only a modification of the processes previously examined, differing in the manner in which the liquid is separated from the powder. It is simple in operation, easy in manipulation, and productive of satisfactory results when properly applied. It is called percolation, under which name we shall perhaps be led to examine some points of interest connected therewith, and some modifications which have been suggested as improvements over Prof. Procter's process, very properly denominated simple percolation.

Prof. Procter, in bringing before pharmacists this process to deplete a powder of soluble matters, laid no claim to originality, excepting in the application of the principle for the purpose of making tinctures and fluid extracts. He certainly was aware that the process had been in use, for a similar process was recommended by Count Rumford for preparing coffee; and in 1817, C. Johnson applied the principle to the extraction of cinchona bark, saying: "The machine I use is similar to one made several years ago by Edmund Lloyd and Co., and does not differ essentially from any of those described in Count Rumford's eighteenth essay, and in the 'Repertory of Arts,' for April and May, 1813." Of the practical application of the process, Johnson remarks, "that in the Lancaster Public Dispensary this method is found to afford a better preparation than was formerly obtained from twice the quantity of cinchona."

Pelouze, as early as 1834, introduced percolation into the laboratory of the chemist in his method of preparing tannic acid, calling it "extraction by the process of displacement." Virtually, percolation has been employed for ages before with civilised and even partly barbarous nations, as, for example, in making saltpetre and potash.

In conducting percolation, the object being the preparation of fluid extracts, many points are essential other than the considerations mentioned heretofore. Of those the most essential to be considered are the vessel employed, the material operated upon, the menstruum used, and the manner of manipulation. Accepting the argument that percolation is for the economical extraction of soluble materials, it is of the utmost importance to study influence of contact between the menstruum and the material whose partial solution is to be effected, as we have already seen that contact, continued for a length of time, is of first necessity. Thus, if we place 1 lb. of powdered sugar, or any other soluble substance, within a cylindrical percolator of such diameter that the space occupied is 1 in. in height, and cautiously add, evenly upon the upper surface, diluted alcohol, admitting for the sake of argument that the menstruum passes evenly and regularly through the powder, the diluted alcohol in the first of the percolate will have been in contact with 1 in. of material. That which follows will have successively less material to operate upon, for the first portions of percolate are partly made up of dissolved sugar or extracted matter. Thus each preceding portion of the percolate lessens the material in the percolator, and lessens the height, thus decreasing the contact of any that may succeed, until finally only a thin layer of sugar remains, between which and the passing menstruum the contact is very slight indeed. At last the sugar disappears. For this reason, even where the material is completely soluble, our percolate should theoretically become less and less charged with dissolved matters as percolation progresses (unless it be saturated to a certain point of the percolate), and at last a comparatively large amount of menstruum should contain but a small amount of dissolved material.

Let us now imagine a like amount of powdered sugar in a percolate of less diameter. The height will be increased and the contact between the first part of percolate and powder will be greater in proportion to the increased height. Allowing, for argument, the material to occupy 8 in. in height, it will follow that the menstruum of the first portion of percolate will have passed through 8 times the height of sugar that the corresponding portion did in the former experiment, although the real amount of sugar was the same. Now again we have the afore-mentioned rule regarding decrease of contact. Each successive part of the percolate lessens the sugar in the percolator, and decreases the possible contact (with sugar) of all the menstruum that may follow, and under like motion of liquid the sugar decreases in each succeeding part of the percolate. It will be seen that, theoretically, each portion of the menstruum in the smaller percolator must have greater contact with the material than the corresponding menstruum of the larger, if both percolate with the same rapidity, although in both examples we operate upon similar amounts of material. Arguing therefrom we are induced to anticipate that unless the percolate from the percolator of greater diameter is saturated with sugar, that which corresponds from the smaller will contain more dissolved matter, for after 1 in.—the depth of sugar in the percolator of greatest diameter—is passed there remains in the smaller 7 in. of contact during which solution may progress. Calculating accordingly we may expect that if we spread 1 lb. of sugar so that it will occupy a depth of 1 in. in a percolator, and percolate through it diluted alcohol enough to produce 16 fl. oz. of percolate, we will fail to obtain as much sugar in solution as though the sugar had been placed in a vessel of less diameter, thereby increasing the contact between menstruum and sugar. Applying the same rule to larger and smaller amounts of other substances, we must conclude that unless there be counterbalancing influences the amount of dissolved matter in a percolate must increase and decrease with alteration in the height of powder, other conditions being identical, and amount of percolate passing from each in a given time.

Let us not infer, however, that the conditions cannot render the foregoing to an extent inaccurate. If our material be placed loosely in the percolator as a consequence the first portion of menstruum will pass rapidly. If after the first fraction of percolate is obtained the flow be retained by means of a stopcock, that which follows may be held in contact with the material some time longer than the first; after the second fraction is reserved the flow may be again retarded, and thus more actual contact of time induced between menstruum and material than was obtained at first, although there is continually less material within the percolator. With some substances another benefit to be derived by the latter percolates arises from the fact that if the material be not finely divided or pressed firmly into the percolator the first portion of percolate flows over the particles and through the interstices between, thus preventing the menstruum flow coming into close contact with soluble materials. Gradually, however, the material may absorb menstruum, and expanding fill up those interstices, thus forcing the passing percolate to seek more and more the capillary passages through the material, and thus give a larger amount of dissolved material to a portion of percolate succeeding a certain amount of the first. To an extent this result may occur from a somewhat similar cause, even with materials perfectly soluble in the menstruum, as, for an example, sugar or salt. With small amounts of loosely packed granulated sugar the first part of a percolate of diluted alcohol or water quickly finds the exit of the percolator, but the surfaces of the particles are in the meantime softened and the mass contracts. The interstices become filled with thick syrup or solution, and thus the percolates that follow are for a time retarded. It will be noticed that the foregoing discrepancies result simply from imperfect contact, or, as we may say, imperfect maceration.

We will now consider another phase of the subject. Will a certain amount of material, occupying a height of 10 in., yield to corresponding portions of percolate less dissolved matter than a smaller amount in a percolator of such size as to make the height 20 in.? If we accept the foregoing arguments we must conclude this will be the case to a certain point of the operation, unless the percolate from each percolator is saturated, as each drop of menstruum passing through the one will come into contact with a larger portion of material than that from the other, until a certain amount of soluble matter is carried from the smallest amount of material, when it will naturally follow that the percolate from the largest amount of material will contain more dissolved matter. In other words, the first portion of percolate from the material occupying the greatest height will excel the other, while afterwards the case will be reversed. Perpendicular height should govern to this extent the result from this standpoint regardless of quantity. For the greatest contact between powder and menstruums, moving with like rapidity, must be where there is greater height of powder regardless of breadth.

In considering now that phase of contact between menstruum and solid, called maceration, in connection with percolation, one cannot find any influence at work arising from a force other than those simply due to a prolongation of contact before considered. The passing menstruum is retarded, thus permitting a longer time for the action of the solvent. In treating of this entire subject let us bear constantly in mind that our aim is to dissolve solid substances, and that the various modifications of the processes are simply influences affecting solution.

If we close the exit of our percolator at any time during the progress of percolation, the menstruum within the percolator will necessarily cease to move bodily downward. The liquid will thus remain in direct contact with the material, and as a consequence the act of solution will progress in a manner similar to that exemplified by our example of the dissolving crystal of potassium bromide. Hence, it is evident that no other advantage than those resulting from longer continued contact can arise. To guard against any disturbing influence affecting succeeding percolation, caused by an unequal contraction of the only partially saturated powder, it is to be observed that all particles of material are equally and permanently surrounded by menstruum. We must bear in mind that the action of the menstruum upon the powdered material in the percolator, which consists of a number of small fragments, and that upon the single crystal of potassium bromide, in the example cited heretofore, differ only in degree; its solvent power affects alike all the molecules exposed to its influence, and the relative difference is dependent solely upon the difference of the areas of surface exposed to contact. In fact, the term molecule implies no definite idea of size, and is an expression applying to something beyond our senses; we cannot compare the molecules of a liquid to particles of matter of any conceivable size. We are forced to assume that a menstruum is made up of an inconceivably large number of infinitely small particles, which we consider capable of permeating the powder within the percolator, finding its way through the capillary channels which surround the particles of the solid, circulating around them in obedience to laws already considered, and according to influences yet to be mentioned. During the process of maceration in the percolator the capillary tubes, as well as the larger interstices, are supposed to be filled with liquid; if this liquid be capable of dissolving wholly or partially the solid, solution must take place. Each successive movement of contact is found to decrease the quantity of matter held in solution until the liquid is saturated or the solid dissolved. Thus we find the effect of contact in percolation to be identical with that in simple maceration.

In percolation, from the instant the stratum of menstruum commences to penetrate the material until it escapes, we have maceration connected with alteration of the position of the mass of the liquid. There are continually new surfaces of contact formed as the liquid passes downward towards the exit of the percolator, and in maceration this phenomenon is also presented. There is no rest within the vessel while solution progresses. Mediums of greater specific gravity than the original menstruum are constantly forming, which, obedient to gravity, seek the lowest portion of the vessel, in turn to be displaced by heavier liquids. In this way, during maceration numbers of percolating currents are flowing throughout the capillaries, and between the interstices of the material, as in percolation, while fresh portions of liquid are continually coming into contact with new surfaces, and saturations are giving way with perfect regularity to those not saturated.

Thus circulation of currents progresses and will continue until an equilibrium is established, as long as there is soluble matter and unsaturated menstruum within the percolator, and afterwards whenever the temperature is permitted to change. Therefore maceration cannot be disconnected from percolation, and as we have seen percolation must include maceration. Thus the contact of maceration and the contact of percolation are identical. Reasoning from the foregoing it may be argued that the expression, maceration in connection with percolation, is simply an expression to imply prolonged contact of liquid with material, by which means we may overcome a defective contact of height of material within the percolator. Upon the other hand, increase of height of powder may imply prolonged maceration of the material with successive portions of menstruum.

We may be justified in arguing that the influences which modify contact are of vital interest in the study of percolation; that the solvent action of the percolating menstruum may be facilitated by judicious maceration, or by increasing the perpendicular height of the powder.

Let us now consider the vessel which contains the material known as the percolator. This is of the utmost importance, as the increase and decrease of diameter governs capacity, subservient to mathematical laws, which it is necessary to examine.

The percolator controls the height of powder under like pressure. As the diameter of the percolator decreases it is responded to by greater, and as it increases by less height, both of powder and menstruum. Thus, if a cylindrical percolator be 6 in. in diameter, and a given amount of liquid or powder occupy a height of 6 in., the same material will occupy :—

13½ in. in height in a percolator 4 in. in diameter; 24 in. in height in a percolator 3 in. in diameter, and 54 in. in height in a percolator 2 in. in diameter.

This is in conformity with the mathematical law that the height of both liquid and powder increases inversely as the square of the diameter of the percolator; a rule, however, which does not apply to the increase and decrease of the resultant contact between the material and passing liquid, as a more careful examination will illustrate.

Let us represent contact by numbers. If a cylindrical or prismatic percolator be used which has been filled 1 in. with a powder, overlying which is alcohol to the depth of 1 in., it is evident that every particle of the powder which assists to form any perpendicular line or column of the powder 1 in. in height will be exposed to and come into contact with every collection of molecules in the line or column of alcohol perpendicular above providing the alcohol passes directly through the powder from top to bottom. If we knew the number of particles of powder and the number of molecules of alcohol in their respective columns, by multiplying the numbers together the product would represent the individual contacts between particles and molecules. As before remarked, we cannot calculate the number of molecules in a given bulk, therefore we will simply call the inch of alcohol and the inch of powder one, and thus by multiplying one by one we have the product one, which we will take as unity. If the powder be 2 in. in depth and the alcohol be 1, or if the alcohol be 2 in. in depth and the powder 1, the contact will be twice as great (2 × 1 = 2), and may be represented by 2. If both are 2 in. in depth, the contact will be (2 × 2 = 4) twice as great as the last, or 4 times that of the first, and may be represented by 4, and so on. Let us now take a percolator and apply the foregoing law of increase of contact. For the sake of obtaining even numbers we will consider a square prism instead of a cylinder, as the principle applies alike to either, although in practice cylindrical percolators are employed.

The area of the base of a square prism 16 in. in diameter is 16 × 16 or 256 sq.in. If a powder properly moistened for percolation be placed in it to the depth of 1 in., above which rests 1 in. of alcohol, there will be 256 cub. in. of each layer, and yet being taken as unity when the alcohol has passed through the powder the contact will be 1 × 1 = 1, and thus the contact may only be represented by one. If a square prism 8 in. in diameter be considered, the area of the base will be 64 sq. in. If filled with powder to the depth of 1 in., over which rests 1 in. in depth of alcohol, each layer will contain 64 cub. in. of material, or ¼ the amount required to fill the 16 in. percolator 1 in. in depth. The 8-in. percolator would therefore have to contain 4 in. in depth of each alcohol and powder before the amount (256 cub. in.) could be reached. Thus the contact will be 4 × 4 = 16.

A prism 4 in. in diameter must be filled 16 in. in depth with both alcohol and powder to contain 256 cub. in. of each material. The contact will consequently be 16 × 16 = 256. Thus continuing our calculations, we have the following table which expresses the contact between material and liquid, in each instance the percolator below being ½ the diameter of that above :—

Percolator 16 in. in diameter, alcohol and powder each 1 in. deep, contact, 1.

Percolator 8 in. in diameter, alcohol and powder each 2 in. deep, contact, 16.

Percolator 4 in. in diameter, alcohol and powder each 16 in. deep, contact, 256.

Percolator 2 in. in diameter, alcohol and powder each 64 in. deep, contact, 4096.

Percolator 1 in. in diameter, alcohol and powder each 256 in. deep, contact, 65,536.

It will be seen that with the percolator 1 in. in diameter there will be 65,536 times as much contact between alcohol and powder, inch for inch, as in the 16-in. percolator. Thus we find that whereas the height of both liquid and powder increases inversely as the square of the diameter of the percolator, the contact between liquid and powder increases inversely as the fourth power of the diameter of the percolator.

As we follow a line of experiments, the solution or partial solution of one problem brings us face to face with others. Thus we are led onward, and the more thorough our study of the present, the more important we find it to carefully note the future. The utmost caution is necessary in studying nature's laws, lest from insufficient data we hastily generalise. The foregoing argument regarding the laws of contact is undoubtedly as accurate, from a theoretical view, as those of the mathematical increase and decrease of the capacity of the percolator. In practice, however, the advantage derived from increased contact of height between liquid and powder, is not by any means as great as the foregoing calculations indicate. Counteracting agencies overcome to a very great extent the theoretical advantages contact should afford.

Fig. 153 shows an arrangement suggested by Ungerer for the process of repercolation. A number of percolators *a b* are placed on a suitable stand, one above the other, so that the tube of one percolator passes through a cork fitted into the mouth of the one below: 6 to 12 of these vessels may be used one above the other. The stand consists of a board with pairs of projecting pegs placed at such distances that there is room for the cylinder between them. Boards having a horseshoe-shaped piece cut out on one side are placed on these pegs, and serve to support the cylinders in their places. The menstruum is allowed to run into the top cylinder, either freely or (in order to increase the pressure) through a long tube attached to the top. The liquid permeates the substance in the cylinder and runs through into the cylinder below, and so on to the bottom, where it is drawn off as the strongest possible tincture. By adjusting the lowest stop-cock the speed of flow can be properly regulated. The number of vessels and the speed of percolating should be so regulated that the tincture begins to flow from the lowest cylinder just when the contents of the top one have been thoroughly exhausted. As soon as the top cylinder is exhausted it is removed, the whole column of vessels is raised up a stage, and a newly filled vessel is added at the bottom. In this way the process becomes continuous, and a concentrated extract can be made, except, of course, towards the end of the operation.

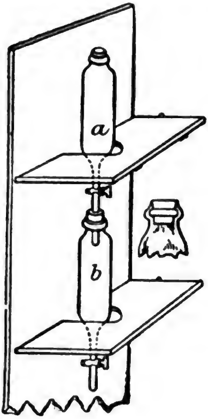

FIG. 153.

FIRE GRATES.

THE WORKING PRINCIPLE AND THE FIXING OF OPEN FIRE GRATES.

(*See also* LAYING TILED HEARTHS, SLABBING TILES FOR GRATES, ETC.)

ALTHOUGH so little can be said in favour of the open fire grate from an economic or practical standpoint, it might be explained that it has one peculiar and advantageous feature which other systems of heating do not possess. This is its method of heat diffusion, the heat being wholly radiated, and affording no direct heat to the air; in acting thus it resembles that great source of natural heat, the sun. It is considered that health is benefited and promoted, and a peculiar sense of comfort derived, from air breathed considerably below the temperature of our bodies, while the body itself, as far as the sensation of comfort is concerned, can enjoy a higher temperature. This is exactly what we obtain with a good grate, and herein lies, most probably, the cause of some of the liking for it. There are, however, limits to both the warmth and the coolness of the air to be breathed, for if much below 40° F. it becomes cooler than the breathing organs care for; while at outside temperatures below freezing point the capabilities of the grate as a heat giver, are considerably strained. On this account the exclusive use of grates in America would be a failure (except in the more southerly states), and a plan, gaining favour in England, of combining radiators with fire grates in the warming of residences has good features. In this method the radiators are only heated when the outdoor temperature is, say, as low as 35° F. There is nothing economical about this arrangement, but it provides for comfort in most people's opinions.

The earlier forms of grates consisted of an open-topped fire-box, with bars in front, and commonly having hobs, or flat spaces, at the sides, as shown in Fig. 154. This form of grate is credited with having a cheerful, home-like appearance (when the fire is alight), and grates of this kind are even now to be had, but of more modern finish. It is, however, used only for effect —sentimental effect, really. It is an extravagant, inefficient grate, and a smoke and soot producer without equal. It also, usually, creates chimney troubles, owing to the large space over the fire (at the mouth of the chimney) in which cold air can rest, and which allows cold air to enter the chimney far too freely. The grate, itself, however, is closely related to the old country-house architecture of England, and to the majority of English women folk it always recalls quaint and pleasing associations; it is the women, of course, who control this sort of thing. As a heat giver this grate is a very limited success, and in practical detail it embodies all that is considered faulty in a grate nowadays.

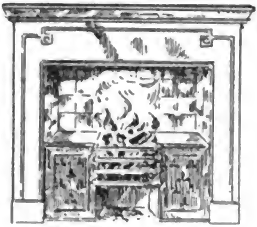
FIG. 154.

By explaining the faults of this grate a good introduction can be given to the perfections of our more modern types, for although this kind of grate is still used, it must not be thought that its use is widespread and general. People are fully alive to the necessity of economising fuel, in other words, getting the most efficient results from it, which also means maximum of heat in the room with a minimum up the chimney, or, in the last analysis, a slower rate of combustion and less smoke production. It has taken a long time for ordinary people to learn and know that smoke issuing from a chimney is so much coal wasted in the air (without counting its ill effects), and every sack of soot the sweep takes away represents, in its compact condition, about three times the volume of coal. Most intelligent people now know this. The sweep, by the way, is an individual whose presence more inclines a lady towards hot water heat than any verbal argument can.

The faults of this grate, Fig. 154, are:—

(*a*) The height of the fire above the floor line does not permit the heat to be felt at the floor level, where it is needed, and where it can give the best general results. A warm floor line counts for much, if it is not everything, in rooms heated by fire grates. The construction of the fire-box is not of such form as will allow heat to flow to or towards the floor line.

(*b*) The form of the fire-box is not such as will project or deflect heat into the room, but, on the contrary, it affords every facility for more than half the heat to be projected or pass into the chimney.

(*c*) The design of the fire-box does not provide for perfect combustion, nor even economical combustion ("slow combustion," as we call it, and as it is intended to be). Without extravagant coal consumption no useful degree of heat can be obtained in the room.

(*d*) The wide area over the fire at the mouth of the chimney favours a poor draught in the chimney, a cooler and more rapid fouling chimney, and many minor ill results. No part of the opening above the fire-box contributes to the efficiency of the grate, but decidedly the reverse.

(*e*) The fire-box is usually of iron, either wholly, or with fire-brick back and iron sides. This provides for waste of heat by conduction, and, still worse, keeps those parts of the fire which are in contact with the iron in a dead or semi-dead state until everything around them becomes intensely hot. It might be mentioned that fire-boxes in modern grates are now always made of fire brick of good thickness, sometimes backed with iron, though not usually.

Another old type of grate, with all the faults that a grate can well possess, is still in use. This is usually known as the "dog-grate," though sometimes called a "fire basket," which seems to be a more correct name for it. This kind of grate is still sold quite freely, the demand owing its existence entirely to the fine appearance of this grate when well set. It is illustrated in Fig. 155, and is a grate that merely stands in a recessed opening (at the base of the chimney), thus giving the tile maker and decorator a free hand in making the surroundings beautiful. The decoration is, therefore, an expensive item, and those seeking the very best effect have to pay rather high for it. The faults described with Fig. 154 all apply to this last grate in an exaggerated form, and it is the exception, not the rule, for a chimney over a grate of this kind to work properly. Another grate is made which, while affording the same opportunity for ornamental effect, gives much more efficient and practical results. This is the "Nautilus" grate, so named because of its curved shell form, illustrated in Fig. 156, the most important feature being right and left top sleeve

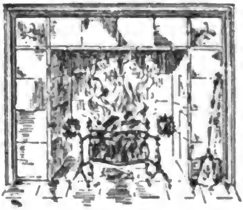

FIG. 155.

connections with the chimney by means of flues brought down in the brick jambs, as shown. The smoke and products of combustion, as they rise from the fire, pass into the curled top and thence pass through the ends of the same into the chimney. It works very much under the same conditions as a stove connected to a chimney by a metal pipe. The recess in which the grate stands is closed at the top, so that there is a sharp draught through the sleeve connections from the curled top of the grate. The draught is, in fact, usually so strong that, as a rule, check-dampers are provided.

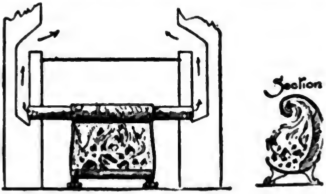

FIG. 156.

After the old-fashioned "hob-register," as the grate illustrated in Fig. 154 was called, came the ordinary "register grate." This was in appearance much like that illustrated in Fig. 157, and its faults are practically the same as those of the hob-register grate, except that this grate seldom exhibited any fault in its connection with the chimney. The exit aperture for the smoke and heated gases was of reasonable dimensions and came immediately over the fire. Cold air had no entrance, or at least, not sufficient entrance to cool the chimney and make it work sluggishly. The earlier forms of this grate had iron fire-boxes, high up and ineffective, and the entrance to the chimney was very favourably disposed to hasten the exit of flame and gases and take the greater share of the heat. The name "register grate" was adopted because there was a register flap working on the opening just described, but this flap could not be regulated ; it had to be fully open or shut, and while the fire was in use it could not be operated at all. It may have been the original intention to make the register flap capable of adjustment, but this was not done. The only use it had was to close the opening in summer.

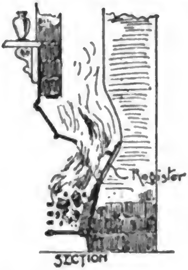

FIG. 157.

The first noticeable improvement on this ordinary type of register grate, was to lower the fire-box and give it a fire-brick bottom. The bottom rested on the hearth illustrated in Fig. 158, and thus the fire itself came within 3 in. of the floor line. This gave decidedly better results, as it reduced the speed of combustion, which had always been too high. At the same time an equal or a higher degree of effectiveness was obtained by the low position of the fire.

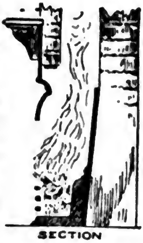

FIG. 158.

This grate and improvements on it have distinctive names of their own, but are all generally alluded to as "slow-combustion" grates. The slow combustion is the result of stopping the ingress of air to the bottom of the fire. The fire-boxes were also lined all round with fire brick, and the total effectiveness was considerably greater than could be obtained with the previous types of grates; the consumption of fuel was at least a fourth less.

The fire-brick bottom of the grate, shown in Fig. 158, had, however, a fault, this being the retention of ash and incombustible debris from the coal burned, so that the bottom of the fire would need to be raked and cleared several times a day, the number of times depending on the quality of the coal.* This led to the introduction of what was called an "Economiser," an ornamental casting fitted in below the front bars of the grate and shutting in the ash-pit as illustrated in Fig. 159. It had the same effect as the fire-brick bottom, preventing the passage of air through the fire bottom, yet permitting a grated bottom to be used. The accumulation of ash did not occur in the fire-box, but worked through the bottom grating as it previously did, collecting in the ash-pit, from which it was removed once daily. This arrangement is still adopted, and answers exceedingly well. In some cases an ash pan is attached to the economiser casting, so as to reduce trouble, and possible escape of dust when removing the ashes each morning. In this case the term "economiser" has been dropped, and ash pan substituted, it being understood that the fronts of these ash pans are always of cast iron and as nearly as practicable fitted air-tight.

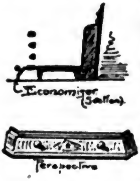

FIG. 159.

When the economiser was first introduced it quickly made itself conspicuous by its effects in old houses where timber existed close under the hearth, or, as was sometimes the case, imbedded in it. The hearth forming the bottom of the ash pit gets intensely hot, and woodwork within 6 in., even with a sound new hearth, is liable to ignite. This has always to be thought of when placing grates in old houses, for all modern grates are alike in this respect. Houses built within the present century are not likely to have woodwork so situated.

I have now considered all real improvements that deal with the bottom of the fire and which have gone into general use; there are other arrangements, claimed to be improvements, but they do not yet command public attention.

There has been but little actual improvement in the front grate bars. Perhaps there is little room for improvement. Practically all the earlier grates had horizontal bars, either straight across, or horizontally convex, and of no particular section. Now there is favour shown to vertical upright bars of about ¼ in. thickness with a horizontal top and horizontal bottom bar, as illustrated in Fig. 160.

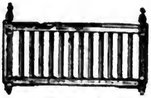

FIG. 160.

These commonly have brass or iron ornaments at each end, on top, as shown. All front bars of good grates are now made removable, so that when the servant goes to clear away the cinders and ashes, she lifts the bars out, removes the ash pan, pulls the bottom grating forward (this not being fixed but standing on legs) and is thus enabled to clear the fire-place quickly and well, without any raking process.

A very ingenious front bar—if it can be called such—was a wire fret of ornamental design, secured on each side by screws or hooks and easily disconnected. It was correctly argued that the wires (about $\frac{1}{8}$ in. thick) did not hide the fire nearly so much as the thicker bars did, and the cost of the wire work being but a trifle, a spare fret was given with each grate. The frets lasted much longer than would at first be thought likely, but they have not been generally adopted.

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* It might be mentioned that the benefits of the fire-brick bottom were sought to be attained in existing grates by cutting and placing a piece of sheet iron over the bottom bars. This was always a failure, owing to the high conductivity of the iron, which caused the fuel at the bottom of the fire to keep in a dead state.

There is a fire front made which consists of horizontal bars, extending from side to side, as usual; but the bar, which has a flat section, slopes, as illustrated in the section, Fig. 161. Two things are claimed for this bar: (1) It keeps a clean hearth, as cinders, live fuel, and ash do not roll or fall out; (2) A better view of the front of the fire is obtained than with ordinary horizontal bars. The line of vision is not horizontal a few inches above the floor line; it commences about 5 ft. from the floor, and descends to the fire, the angle of descent varying a little with the distance a person stands from the fire.

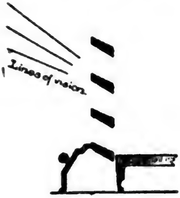

FIG. 161.

A detail in which very real improvement has been made is in the shape of the sides and back of the fire-box, not only where the fire rests, but above the fire, where the heated products of combustion previously made their way into the chimney. The entrance to the chimney has by this arrangement been removed as far as practicable from the fire, and it does not allow a volume of cold air to rest in the mouth of the chimney, as was the case with grates illustrated in Figs. 157 and 158. All fire-boxes are now lined with fire bricks, and those extend up from 18 to 24 in. above the fuel space. Previously the backs, whether iron or fire brick, sloped back towards the chimney with the object, we must suppose, of giving an easy unobstructed passage for the smoke to the flue; for, as stated, the earlier grates had strong inclination to cause trouble by delivering some of their smoke into the room. With the modern backs, the slope of the bricks is, at some point, always forward. This causes no trouble with the smoke, but materially increases the utilisation of the heat from the fuel consumed. Fig. 162 presents vertical sections of different shapes of back bricks, but the most effective is undoubtedly the last one at the extreme right in the row. This is generally spoken of as the overhanging brick, though a few very correctly designate it the "dog's hind leg." Fig. 163 gives a perspective view of this brick.

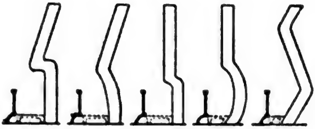

FIG. 162.

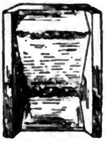

FIG. 163.

The points aimed at with all grate bricks are to give the fullest fire front surface possible, the fullest fire top surface, and to intercept the heat and heated products between the fire and the chimney and exact toll from them by absorbing or redirecting their heat for effective distribution.

That part of the brick, Fig. 163, which is above the fuel, is impinged upon by the rising flame, and gets intensely hot—so hot that when the fire is fully alight no soot collects on it, because all the soot is burned off, and the brick is kept as clean as if new. The result of this is that the fire front is practically extended upwards, for the brick seems but little cooler than the fuel, and this extended front area slopes over in such a way that the radiated heat is projected in the best of all directions, toward the floor. This is one action of the overhanging brick; there is another equally good, but quite distinct in its effects. This is the reflection of heat. Heat acts much like light in this respect, for if a suitable surface is placed at an angle in the path of radiant rays of heat, these rays are turned into a new path or reflected. Fig. 164 will explain this, the ray lines being intended to show the two sets of projected rays, and it will be seen that the enormous radiant energy from the top surface of a glowing fire, which has hitherto been projected into the chimney, is wholly sent into the room, plus the heat abstracted from contact of the flame with the back brick.

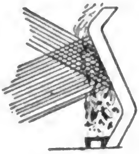

FIG. 164.

The gain in effectiveness from using this brick is positively enormous. The same size of fire that one could sit near to (with feet on the fender) in an old type of grate, is almost too hot to bear at two yards distance, in a good modern grate; whilst its glowing heat and clean flames (for combustion is much more perfect in such a hot area) heighten the sense of comfort and cheerfulness. The general good results are augmented by the brick sides, for these are not at right angles to the back, but are splayed out to about 60°. They, therefore, when hot, radiate heat to the right and the left, the rays crossing, with marked effectiveness.

This practically embraces all that has been included in the "slow-combustion" grate in bringing it up to date, and by this grate a wide open, visible fire, with an effective and economical consumption of fuel, has been obtained. It has now been discovered, however, that the slow-combustion grate is faulty in its most vital part. That is in its slow-burning qualities, for it is always slow. It is very desirable to have a slow-burning fire, when it is actually a fire, burning brightly and evolving sufficient heat; but at first lighting in the morning, or at any time that the fire has got low and wants reviving, the slow way in which the fire burns and behaves generally is very annoying. At first lighting in the morning a slow-combustion grate (a slow-lighting grate in fact) requires starting early if the room is to be fairly warm for the breakfast hour, and while burning up it does little else than pour volumes of smoke into the chimney; and if, when returning from walking, a lady finds the fire low, she has no means of hastening it to the extent she would like.

This brought into existence a grate fitted with a sliding shutter, a "blower" we commonly call it, by which the aperture above the front bars can be closed, more or less as required, from the top downwards. The effect of reducing the height of this opening is to cause the air, which is constantly entering the chimney, to pass closer over the fire, or through it, making the combustion active, as in a close fire stove.

By this means a bright fire can be obtained in quick time, and the production of smoke and soot is greatly lessened. If viewed from an elevated place some of the London suburbs, during the first two hours of a winter morning, present to the sight forests of chimneys pouring out smoke; but this ceases, or only occurs in an intermittent way, after the pre-breakfast hour, when the fires have become hot and bright. The blower, where it is used (its use is by no means general, more's the pity) almost obviates this, and thus is a public benefit. The headway made by the blower is, however, slow, but no one has a word to say against it, unless it is that by its use very foul and neglected chimneys are likely to have their sooty lining ignited. The blower is not always a sliding shutter. It can be a plate to hang in front, or it can be in the form of a pair of hinged doors.

A last word can be devoted to explaining what we have arrived at in making a fire burn specially slow, so that it lasts in nice condition for a long time when once it is bright and good. This is something slower than what is recognised as "slow-combustion."

One partially successful attempt in this direction provides for checking the draft at the mouth of the chimney by an adjustable canopy. Fig. 165 illustrates this in section, and it will be seen that this canopy or flap, when down, almost closes the chimney aperture entirely, but when lifted it provides for a full opening and free draft. It is not within the province of this article to criticise existing manufactures adversely, but it may be said that the arrangement described is not equal to the following :—

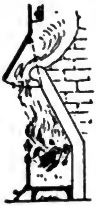

FIG. 165.

It has been found that by soundly closing up the front of a fire-box as well as the bottom, so that only the top is open, an extraordinarily slow rate of combustion can be obtained without the fire expiring or becoming very dull. The fire is thus, we may say, placed in an open-topped box, and the wonder is that it stays alight. There is a strong doubt in my mind that combustion does actually go on, yet the fire remains red and gives out a fair degree of heat, though not so much as when the fire front is open. By thus enclosing the fire at the front, sides, back, and bottom, it is possible to keep it in a red hot state for 18 hours without attention of any kind, and this period of time is given because the writer has had experience of it more than once with a grate in use on his own premises. In this grate there are no special details connected with the fire bricks, the front bars or the bottom, more than has already been described, and the only special feature to secure the result just explained is a pair of well fitted, chambered doors, which are swung out and fit over the front bars when the very slow rate of combustion is required. Of course almost equally good results can be obtained by a casting made to stand in front of the grate and fit close up to the bars. The front is only closed up to the level of the top bar, and no gain is effected by piling the fuel up above this level.

The advantages of the arrangement are many. The fire can be kept alight through the night without attention, no small boon in rooms occupied by invalids, aged or very young people. The fire will keep alight unattended in any room when not occupied, in which case it may be considered that combustion can be temporarily stopped to suit people's convenience. On days when the outer air registers about 45° to 50° and a little heat is needed, this special rate of combustion can be had after the fire has once burned up. A trial of this arrangement strongly impresses one that it is possible to actually stop combustion, yet have the fuel red and apparently burning. It does not, however, appeal much to those who can have radiators in their rooms, as when so arranged the fire is not a pretty one, and does not possess the charm that the open front, briskly burning fire does, with its radiant glow. ('Heating and Ventilation.')

For the general efficient design of the modern fire grate we have to thank Dr. Pridgin Teale, not perhaps for the invention of the details, but for recognising them, together with the necessity of improvement. He delivered a lecture relating to the economical burning of coal in house fires and introduced some excellent rules, which were at once followed, and which have not been improved upon in any great way since. The rules may be summarised as follows: That except for the front bars and bottom bars there should be no metal in contact with the fire. The back and sides of the fire-box (composed of fire-brick slabs) should, above the level of the fire, lean or slope over the fire, and not slope away from it. The lean-over of the back should be at an angle of 70°, the sides much less. The depth of the fire-box, front to back, should not be less than 9 in. The sides of the fire, all the way up should be at an angle from front to back, of 45°. The bottom of the fire should be a grating, to allow the ashes to fall through; but there must be a plate to close in the front opening of the ash-pit. This plate was designated an "Economiser," as by its use air was prevented from passing through the bottom bars, and a slow-combustion fire resulted.

Realising that the heating efficiency of a grate must lie in the extent to which it radiates heat (whether to warm occupants, or the inanimate objects and parts of a room), it was natural to seek for this in the form or arrangement of the fire bricks. To avoid the use of iron in every possible way is essential, as iron is not only a rapid conductor of heat, but its conductivity (in grates) keeps the fire in contact with it in a semi-dead state. The form of the back brick, the section of which has been likened to a "dog's hind leg," has two distinct effects in heat distribution, as it both radiates and deflects heat rays. This has already been shown in Fig. 164, the solid lines representing heat radiated in direct lines downwards from the intensely hot brick; while the broken lines show the deflection or rebounding of heat rays that are projected from the top of the glowing fuel. Very brief experiment will show that heat rays will strike and rebound from a surface (at an angle according to that of the surface) in the same way as rays of light can be deflected by a polished surface. Thus the over-hanging brick affords heat in two ways, while, in addition, its leaning over the fire causes it to become intensely hot, so much so as to burn quite clean and be nearly as hot and effective as the glowing fuel beneath it. Compared with the old register grate it may be fairly computed that this brick alone has increased effectiveness quite 3 times or more. The heat rays from the brick being projected towards the floor has a most efficient effect.

The design of brick suggested by Dr. Teale had a quite perpendicular back where the fire rested against it. In the more modern bricks, while they observe the angles he suggested for the upper part of the back and the sides, do not have the part immediately behind the fire quite perpendicular. Reference to Fig. 163 will show that it slopes forward at the bottom, the bottom grating of the fire thus being made quite narrow from front to back. This design of brick lessens the bulk of fuel at the back bottom angle where a thick fire serves no specially good end.

The most recent innovation in open-fire grates is the "Well-fire," or some modification of this (of which there are a number). With this the fire-box may be described as a square pan or shallow well (about 4 in. deep) sunk in the hearth. The actual sinking is deeper than this to accommodate a bottom grating in most cases, the depth above the grating being 3 in. to 4 in. Such grates embody the details recommended by Dr. Teale, but they do not have front bars (or if they have front bars, they are made to fall down or be removed as required). With most of these grates the fire well is made or sunk in a raised hearth, for it is not always possible to cut out the depth required in an existing hearth. The desirability of the raised hearth also appears in the fact that it admits of a horizontal air passage being taken to beneath the bottom grating of the fire, a hit-and-miss ventilator regulating the flow of air through this passage. By this means a current of air can be admitted to the bottom of the fire (like drawing away the economiser with an ordinary grate) to brighten the fire or hasten its lighting and burning; while by closing the air passage the current of air is stopped and the effect of a closed economiser is obtained, i.e. no admission of air to the under side of the fire. The well fire, also the modified forms of this, are highly effective, not more so perhaps than a modern grate built on Teale principles, but the absence of front bars makes a prettier fire—a more natural looking fire, if it may be so expressed. Care has to be exercised in fixing these grates, as they cause the hearth to become intensely hot. It is only the presence of wood beams, in old houses, that necessitates the care.

In the fixing of register grates there are two details that should be carefully observed to ensure successful results, but, strange to say, both these things are greatly neglected, with the result that large numbers of grates are not working as well as they should do, while failures often occur and are attributed to the grate being unsuited to the room or the chimney. The two things that should be done when fixing any kind of open grate are (1) to make the fixing air-tight all round the edges so that no air can enter the chimney except by passing in by the legitimate entrance over the fire; (2) to fill round the back of the grate solidly with brickwork or concrete. As stated, these two things are much neglected, but the manufacturer has to be largely blamed for this by making the work so difficult to do in many cases. With the modern "interiors" these suggestions can be carried out, but with the older or any type of grate, with ironwork extending over the whole width and height of the opening, the case is very different. Anyone engaged in the trade knows that to fix the old pattern register and then to fill in solidly and well through the register-opening was a most difficult task, and in spite of improvements the more modern grate, consisting of an iron front and fire-brick back, is still often a problem to the fixer. Difficulty arises from the fact that when fixing the front it has, by a band or some means, to be firmly secured to the back bricks, for it cannot be stuck on to them or held in position firmly by any other means. In many grates, although the front and back may be quite separate when delivered, they have to be braced or banded together before being set in place or fixed, and then there remains only the gap at the top, where the smoke passes from the grate to the chimney, through which to fill around the back of the grate. It is not an easy job, yet to make a proper fixing the fixer has to fill round the back somehow, and it must be a sound air-tight job. Examination of a number of grates already fixed will show that the filling is seldom properly done, while often it appears as if it was never attempted. It should be done, however, and can be done, but it needs care and patience to do it. It usually means that some mortar concrete has to be made of small material, and this has to be dropped trowelful by trowelful down the back, using what care is possible to get it to drop and settle solidly all round. As a rule, we fear that the job is but seldom done as carefully as this. The filling is done with coarse stuff, and to get the fixing air-tight a little cement is worked in round the front joint. This cement sometimes fetches the japan off where it touches, and in almost all cases it does not remain sound more than 24 hours after the fire is ignited. Let anyone that will go to any register-grate that is fixed, and, after closing the register-plate, offer the flame of a lighted taper to the joint round the edge of the front casting where it comes against the mantel-piece. There are few cases in which air will not be found passing in at the joint, and this leakage tends to make the grate work badly, and not infrequently causes a more or less noticeable failure.

It will be recognised that there is a second reason for filling solidly around the back of a grate, this being to prevent soot falling and collecting there. If there is a space for soot to accumulate it must, at some period, catch alight and cause trouble, if not damage.

The fixing of an "interior" is a much easier task. This grate consists of the bricks which form the back and sides of the fire-box, and an iron front frame which carries the register or canopy and the front bars. The width of this ironwork is about 18 in., and as the width of the mantel-piece opening is about 3 ft., there is good space each side of the interior for the fixer to do the filling-in soundly and well. The iron front is made to come and remain securely against the bricks by means of iron bands (bolted to the iron front and going round the back of the bricks) so that after securing the parts together and standing the whole on a level hearth, in the opening, the fixing and filling round can be done both easily and well. As a rule, it will be found best to use iron cramps to anchor the interior to the back wall, and the same applies with the full register grate (when possible), unless it is wide enough to come behind the mantel-jambs. The object of this is to prevent the grate "walking out into the room," as the workmen express it. Expansion and contraction, which are always going on, will cause a grate to move forward unless it is anchored. Cramps are seldom sent with grates, but the fixer should obtain or make them. Light rod-iron is the best thing to use. Some men use hoop iron, but it is not so good.

In completing the fixing of an interior the opening will be built up solid each side to a distance and angle that will admit of the tiled sides or splays being fixed. The tiles may be cemented direct on this brickwork, or they may be slabbed panels that will be fixed in front of the brickwork. The fixing of tiles for this purpose and for tiled hearths, is described under "Tiling for Hearths, etc." and "Slabbing Tile Panels for Grates."

When a dog or basket grate (as Fig. 166) has to be fixed, the first thing to be done is to tile the opening, back and sides, and the hearth. These grates are never chosen for their effectiveness, but always for the good appearance obtained by the tiled opening; therefore, this latter detail is of the highest importance and must be done well. When the tiled opening is ready, the grate is placed in position, and the fixing is then considered finished. On lighting the fire, the smoke rises and makes for the aperture of the chimney above, but the movement is sluggish and heavy. Something seems to be preventing the free exit of the smoke, some of which curls and oozes out beneath the mantel-frieze into the room. The trouble may be pronounced, or may take the form of a scarcely perceptible odour of smoke in the room. In all cases, however, the cause is due to the free inflow of cold air to the chimney, air which is not warmed by passing over the fire or near to any hot surface, air which is heavier than the smoke and heated gases which are rising from the fire. It is just the same as with the open range, and the same remedy has to be adopted. A common remedy for the smoking of dog-grates is a blower, but as dog-grates are never fixed in any but the best rooms the tin blower,

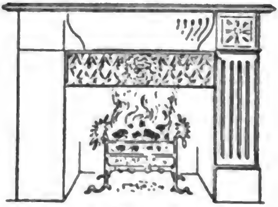

FIG. 166.

familiar with the open range, cannot be used. It can, however, be made of a bevelled-edge sheet of glass, or leaded glass, in a brass frame, as shown, and then proves more ornamental than otherwise. The blower causes the air which passes into the chimney to pass near to the fire, where it is heated. The depth of the blower is obtained after the grate is fixed, when, on lighting the fire, strips of paper can be pasted across the opening to ascertain the depth needed to prevent the smoking. Of course, in some cases no blower is needed.

What is a rather better plan than using a blower is to make an ornamental trumpet-mouthed flue pipe, and fix it so that it comes, mouth downwards, directly over the fire, but about 18 in. above it. If the grate is, say, 18 in. wide and 10 in. from front to back, then a 12-in. by 7-in. square pipe could be made of sheet copper or brass, polished or otherwise finished in good style, with its mouth opening out to about 20 in. by 14 in. This would be fixed, mouth downwards at the height described, with the upper end going into the chimney about 6 in. above the lower edge of the mantel-frieze. At a level with the edge of the mantel-frieze, the chimney must be closed with a sheet-iron plate, fitting closely around the square pipe, and this plate should either be movable or have a door in it to admit of the sweep cleaning the chimney. Whichever provision (for the sweep) is made the plate and its parts should be very close fitting, as near air-tight as possible. If a dog-grate has this tubular flue over it, it will work much under the conditions of a modern grate or interior, successfully and well. The rule has been for dog-grates to be considered very troublesome and seldom really successful.

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FIRE-PROOFING, FIRE-PREVENTING, FIRE-EXTINGUISHING COMPOUNDS AND APPLIANCES.

(*See also* CEMENTS, CONCRETE, SILICATE COTTON, ETC.)

THE following article, intended chiefly to deal with the subject of fire-proofing, has necessarily to touch upon fire-prevention and fire-extinguishing, therefore the whole are grouped as the heading shows.

Fire-proofing Timber.—(1) By Payne's process, patented in 1841, the timber is enclosed in a close iron vessel in which a vacuum is formed. A solution of sulphate of iron is then admitted into the vessel, which instantly insinuates itself into all the pores of the wood, previously freed from air by the vacuum, and after about a minute's exposure, impregnates its entire substance. The sulphate of iron is then withdrawn, and another solution, of muriate of lime, thrown in. The two salts then react upon each other and form two new combinations within the substance of the wood—muriate of iron and sulphate of lime. Timber thus treated is preserved both from rot and from the attack of worms, and is perfectly incombustible.

(2) Dr. Burnett's process consists in treating the timber to a solution of chloride of zinc, 1 lb. chloride of zinc to 4 gal. water. It requires to be immersed for about 2 days for each inch in thickness, and afterwards left to dry for a period of 14 to 90 days. This renders the wood incombustible, but not so thoroughly so as the former process. It is likewise a preservative

(3) There are many chemicals employed to render articles uninflammable, such as common salt, sulphate of ammonia, tungstate of soda, etc. The wood would require to be thoroughly dried, and then saturated with one of the above salts dissolved in

water. The woods least inflammable are beech, oak, American elm, plane-tree, and other non-resinous woods.

(4) A trial at Devonport Dockyard, ordered by the Admiralty, of the method of rendering wood uninflammable by saturating it with tungstate of soda, showed that the prepared wood is under all circumstances much less readily inflammable than ordinary wood; that shavings and chips of the prepared wood, although they may be made to burn, cannot be made by themselves to set fire to substantial timbers of the prepared wood; that prepared timber steadfastly resists mere flame, although it may be made to burn when acted upon continuously by great heat. The cost of preparation and the largely increased weight of the prepared wood are disadvantages to be set against these advantages.

(5) Wood can be rendered practically fireproof by first drying it thoroughly and then coating it with common whitewash. If the wood is not thoroughly dry, the coat of whitewash shells off, but it is a very difficult matter to burn wood which has been plastered over with whiting or even limewash.

Paterno reviews several substances which are used; some of them, as sodium tungstate, answer very well, but are objectionable, on account of cost. The author has made numerous experiments with various substances in their power of rendering fabrics uninflammable. He recommends the following as being quite equal to sodium tungstate.

(6) A mixture of borax and sulphate of magnesia. To prepare this, for 20 lb. water take 3 lb. borax and 2¼ lb. sulphate of magnesia. The action of this mixture depends on the formation of a borate of magnesia, insoluble in water, hot or cold, which surrounds and impregnates the threads of the texture or the fibres of the wood, and thus renders the development of combustible gases and the spread of flame very difficult.

(7) A mixture of sulphate of ammonium and sulphate of lime, or gypsum, in various proportions according as it is to be applied to materials of greater or less fineness. The sulphate of lime is transformed, with the salt of ammonium, into a double compound, which produces none of the disagreeable effects of the latter, or at least in a very slight degree. The action of this mixture of salts—which on account of its cheapness may be extensively employed—depends on an incrustation of the fibres, which prevents the spread of fire, and on the other hand, extinguishes flame in consequence of the volatilisation of the salt of ammonium at a high temperature. Take 1 lb. liquid ammonia and 2 lb. sulphate of lime, and a single coating with a concentrated solution of this compound, which coats little, suffices to preserve wooden structures from burning. The wood is not rendered absolutely incombustible, but it is not easy to light, and ceases to burn when the action of foreign inflammable substances come to an end. Roofing often washed with rain water, and presenting every condition favourably for easily taking fire, was impregnated with this mixture. It had been covered with a layer of tar and drying oil, and thus renderd more liable to burn. Nevertheless, all attempts to set it on fire failed. The experiments made have been so satisfactory that the Austrian Minister of Finance has recommended this method to be used in all the establishments of the empire. ('Oest Zeit für Berg-u-Hüt.-W.')

(8) Make a saturated solution of 1 part green vitriol and 3 parts alum. Paint wood twice with this, hot, letting the first coat dry before applying the other. When second coat is dry, paint over with a weak solution of green vitriol in which pipe-clay has been mixed to the consistency of paint.

(9) Wood cannot be rendered incombustible, or more strictly speaking non-alterable by heat; but its non-inflammability may, to a considerable extent, be ensured, so as to preserve

buildings from a limited and temporary fire, at any rate until assistance arrives. It is, however, hopeless to expect a building encumbered with inflammable substances to pass through such a test uninjured.

The methods of preserving wood against fire are of two kinds: the injection of saline solutions, and the application of a paint or coating. The former appears but little practical; and indeed, short of proof to the contrary, it must be considered dangerous in the case of wood of large dimensions. This system is, however, applicable to small pieces of wood. Of all the substances recommended, a concentrated solution of phosphate of ammonia is undoubtedly the best, the use of this substance, notwithstanding its high price, possessing such great advantages that it should be employed in all cases where expense is no object. In the majority of cases, however, coating with a brush is the only practical solution of the question, and the substances most to be recommended for use in this manner are cyanide of potassium and asbestos paint.

(10) The following treatment of wood is alleged to render it incombustible without any alteration in appearance. Intense heat chars the surface, slowly and without flame, but does not penetrate to any extent, and leaves the fibre intact, whereby in case of fire the firemen would have no occasion to fear that the materials on which they tread would give way beneath them, if this operation had been undergone by the wood composing the staircases, floor, etc. The chemical compound said to produce the result is: Sulphate of zinc, 55 lb.; potash, 22 lb.; alum, 44 lb.; oxide of manganese, 22 lb.; sulphuric acid of 60° Tw., 22 lb.; water, 54 lb. All the solids are to be poured into an iron boiler containing the water at a temperature of 113° F. As soon as the substances are dissolved, the sulphuric acid to be poured in little by little, until all the substances are completely saturated. For the preparation of the wood it should be placed in a suitable apparatus, and arranged in various sizes (according to the purposes for which it is intended) on iron gratings, care being taken that there is a space of about ½ in. between every two pieces of wood. The chemical compound is then pumped into the apparatus, and as soon as the vacant spaces are filled up, it is boiled for 3 hours. The wood is then taken out and laid on a wooden grating in the open air, after which it is fit for use.

(11) Make a bath of, say, 50 gal. of water, in which ½ lb. alum and ½ lb. sulphate of copper are dissolved. These two chemical substances should be dissolved in a little hot water then added to the bulk of cold water. Put the timber in this, keeping it immersed by loading with stones. Let it steep for 4 or 5 days, then take out, and dry thoroughly before use.

Buildings.—The following observations are due to the late Capt. Shaw:—

To construct a building in such a way that it will resist the effects of heat and flame for any considerable time requires care and forethought in the choice of the position, a sound knowledge of the several materials to be used, and a skilful design to bring these materials into combination in such a way as to meet the proposed requirements of the structure when completed, and at the same time to avoid the consequences of extreme and sudden changes of temperature; for it should be known that some of the greatest destruction ever seen after a conflagration has been caused, not by the primary, but by the secondary effects of fire; that is to say, not by the expansion produced by heat, but by sudden contraction after the expansion. In choice of materials there is much food for reflection in connection with the safety of buildings when exposed to sudden changes of temperature. In walls, bricks of any kind, but more particularly fire-bricks, if properly laid in sound mortar or cement, will resist the effects of heat for a considerable time; stone, if laid as well in the middle as on the inner and outer surfaces, lasts a long time, unless it fails in the unsupported parts over the opening, which it always does when lintels and the tops of the windows are made of the same material. Openings for doors and windows in the stone wall, to be safe, should be mounted on the top with brick arches, which would carry the load without any difficulty long after stone in such a situation would have become calcined, and probably allowed the whole of the superstructure to fall down. For stairs, stone is a very dangerous material, unless it is embedded on some substance which can carry it when it gets hot. Stone stairs are usually made by tailing in the ends of a number of blocks of stone a few inches into a wall, leaving some 2 or 3 ft. protruding, and hanging unsupported in mid-air. After such stairs have been completed, they present an imposing appearance of solidity and strength, and so deceive the eye; but if fixed at a height of 30 or 40 ft., and even at the ordinary temperature of the atmosphere. the block would be somewhat fragile. There can be no doubt that any sudden rise of temperature, such, for instance, as might be produced by pouring a kettle of boiling water on it, would suffice to bring it to the ground. In this case, the exposed part would expand with the heat, the supported part, being protected, would not expand, and a fracture would occur between the two, generally close to the wall. Such are some of the principal dangers of the use of stone, but of all building materials there is none which require more extreme care and delicate treatment than iron. Imagine a straight iron rod supported only at its ends, and capable, at the ordinary temperature of the atmosphere, of carrying a heavy weight in the middle. Let a strong fire be lighted under it: in a few moments the rod will lose its straightness, first sagging in the middle, then dropping altogether, next fusing, and finally running away; yet this is a material which many persons persist in calling fireproof, and put to carry loaded floors in buildings which they designate by the same improper epithet. The employment of these materials cannot be prohibited. Therefore greater reason exists for exposing their weakness in respect of withstanding fire, and pointing out necessary precautions in their use. Wherever iron is used it should be protected by terra-cotta, good brickwork, sound plastering, or, if nothing better can be found for the purpose, solid wood-work round it. Woodwork, if really sound and solid, will resist for almost any length of time every possible effect of heat short of actual flame; even when flame has reached it, it is by no means destroyed at once, but, on the contrary, is sometimes found to last for hours; and wood protected on its under side by proper plastering, which will not fall down or crack on the application of heat, seems to be a most powerful resister of flame. It is probably to the scamping now so common that we owe the diminishing use of timber as a material for the construction of buildings destined to carry heavy loads. In this country, ceilings are made to look solid enough, and, if they were only what they represent themselves to be, they would in most cases be almost impervious to the effects of either heat or flame; but let them be pierced through, and they are found to be a sham, being a mere skin of plaster adhering to some thin strips of wood, which may be termed indifferently laths or firewood according to the taste of the observer. These strips are tacked on to the lower parts of the joists, and the spaces between them and the flooring boards over the joists are simply so many flues, commonly containing very foul and noxious air, but capable at any moment of being converted into most dangerous hidden passages for smoke and flame. Air-passages are also found in the lath-and-plaster partitions between rooms, behind the skirting-boards of rooms, and under the steps and behind the skirting-boards of stairs. All sound building is more or less good building for resisting the effects of heat; and all scamping is dangerous.

The fact of the fragile wooden doors of ordinary buildings being the chief outlets for the spread of fire has scarcely been adequately noticed. No sooner is the frail door burnt through, than the fire rushes up the staircase, which thus acts the part of a huge chimney in creating a draught and increasing the fire, being itself a vehicle for transmitting the fire to other parts of the building. Even iron doors buckle and twist under intense heat, and have failed lamentably. There is, however, a description of door absolutely fire-resisting. They are partly constructed of refractory fire-clay, and are made to slide into spaces left in the thickness of the walls. They overlap the door aperture by several inches on all sides, whereby their iron framework is well removed from any possible contact with fire.

It is needless to point out the danger to which an ordinary town house is liable from the ignition of its external woodwork. Safety from external fire may be secured by the application of wired glass to external windows. One further source of external danger lies in the ordinary construction of roofs with wooden framings, generally as dry as tinder, and readily inflammable, even through their slated coverings in most cases. These should be universally superseded by the cheaper, more durable, and fire-resisting flat roof, now proved, by several examples, to be quite practicable when constructed of concrete, or concrete faced with tiles.

Whilst advocating the provision of all available appliances for "knocking out" incipient fire, such as hydrants, hose, etc., the necessity should, above all, be recognised for such construction as would facilitate the safe and rapid combustion—if burn they must—of the contents of any one compartment, rather than risk the contents of other compartments, through accumulated heat, by denying to the flames from a portion ignited a safe and free exit by a recognised channel. To this end a sufficient shaft should be constructed from the ceiling level of each compartment (which ordinarily would prove an excellent means of ventilation) for the purpose of discharging the fire, so to speak, harmlessly up the chimney. The condition of each compartment would be the reverse of an ordinary brick oven, which is constructed to accumulate intense heat without the slightest risk to its surroundings), whereas the arrangement under consideration would provide compartments structurally as non-inflammable as ovens, with the ever-present means of discharging instantaneously accidental fire, whereby accumulated heat would be rendered impossible.

Paints.—(1) Various substances have been proposed as fireproof coatings for the protection of woods employed for building purposes, but most of them have been abandoned as being either too costly or not sufficiently durable. The following invented by Vildé and Shambeck, seems to succeed. The paint consists of 20 lb. finely pulverised glass, 20 lb. finely pulverised porcelain, 20 lb. any sort of stone in powder, 10 lb. calcined lime, and 30 lb. water glass (silicate of soda), such as usually found in commerce. The solid elements, having been powdered as finely as possible and then sifted, are moistened and then intimately mixed with the water glass. This yields a mass of syrupy consistence that may be employed for painting either alone or mixed with colour, such as Venetian red, Indian red, oxide of iron, yellow ochre, sienna and umber. The addition of the lime gives a certain unctuosity to the mass for whitewashing, and its combination with the silicic acid of the soluble glass serves to bind the other materials together. The proportions of the different elements above mentioned may be changed save that of the water glass, which must remain constant. These elements may even be replaced one by another; but it is always well to preserve the lime. Instead of the silicate of soda (soluble glass of soda) soluble glass of potash might be used, but the former is less expensive. The coating is applied with a brush, as other paints are, as uniformly as possible over the surface to be protected. The first coat hardens immediately, and a second one may be applied 6 hours or more afterwards; two are sufficient.

(2) Take of common lime, freshly slaked, of hydraulic lime, and of silicious or argillaceous matter (sand or pulverised slate) equal parts; to which add cows' milk in sufficient quantity to give the whole when thoroughly mixed the proper consistency for laying and spreading with the ordinary brush. Any desired colouring matter may be added. The addition of glue or rosin may in some cases be of value. The proportions may vary considerably, but those above given are considered to produce the best result.

(3) 20 lb. asbestos powder, 5 lb. lime, 5 lb. aluminate of soda, 15 lb. silicate of soda. Add any colouring material as required, as described in (1), and the necessary amount of water to make it of a consistency that can be used with a brush as a paint.

(4) Two substances are in general use for the purpose of protecting wood against combustion, viz. zinc chloride and soda silicate. Both of these have certain drawbacks. A paint consisting of zinc chloride volatilises when the material on which it is spread is heated or exposed to flame and its vapours are unsupportable by human beings. It would therefore be difficult, if not altogether impossible, to enter wooden dwellings painted with zinc salt when on fire, and thus the salvage of furniture, etc., would be obstructed. The water-glass paint, on the other hand, is liable to be washed away when exposed to rain or other watery influences. Sieburgur therefore recalls to mind two fireproof compositions which were formerly in much use. The one is a saturated aqueous solution of 3 lb. alum and 1 lb. copperas, with which the wood is twice painted; after drying a solution of copperas in which powdered clay is suspended, is brushed over the alum layer. The other protective paint is a mixture of 1 lb. sulphur, 1 lb. clay, and 6 lb. copperas, spread as powder over wood previously washed with a solution of glue. ('Ding. Polytech. Jl.')

(5) Mountford's paint consists of asbestos ground and reground in water, potash or soda aluminate, and potash or soda silicate. When it is to be exposed to the weather, it is combined with oil, driers, and gummy matters, and in some cases with zinc oxide or barytes.

(6) It is found that a most effective composition for fireproofing exterior surfaces may be formed by slaking a sufficient quantity of freshly burned quicklime of the best grade, and when the slaking is complete there is added such an amount of skim-milk, or water in its absence, as will make a liquid of the consistency of cream. To every 10 gal. of this liquid are added, separately and in powder, stirring constantly, the following ingredients in the order named: 2 lb. alum, 24 oz. subcarbonate of potash or commercial potash, and 1 lb. common salt. If white paint is desired, no further addition is made to the liquid, though the whiteness is found to be improved by a few oz. plaster of Paris. Lampblack has the effect of giving a number of shades from slate-colour to black. Whatever tint is used, it is incorporated at this stage, and the whole, after being strained through a sieve, is run through a paint-mill. When ready to apply, the paint is heated nearly to the boiling point of water, and is put on in its hot condition. It is found that the addition of a quantity of fine white sand to this composition renders it a valuable covering for roofs and crumbling brick walls, which it serves to protect.

Textile Fabrics.—Several preparations for rendering textile and other inflammable fabrics incombustible and practically fireproof were introduced by Martin and Tessier, of Paris. The compositions are of an inexpensive nature, and capable of rendering incombustible all kinds of readily inflammable substances, such as woven and other fabrics of cotton and other fibrous materials, paper, printed or otherwise, including bills of exchange and other securities, woodwork, theatrical scenery, straw, etc.

(1) The first composition, which may be applied to all kinds of fabrics, without deteriorating them in any way, consists of sulphate of ammonia (pure), 8 lb. ; carbonate of ammonia, 2·5 lb. ; boracic acid, 3 lb. ; borax (pure), 1·7 lb. ; starch, 2 lb. ; water, 100 lb. It is simply necessary to steep the fabrics in a hot solution composed as above until they have become thoroughly impregnated, after which they are drained and dried sufficiently to enable them to be ironed or pressed like ordinary starched goods.

(2) A second composition, to be used for theatrical scenery (or the mounted but unpainted canvas to be used for this purpose) and also for woodwork, furniture, door and window frames, etc., is to be applied with a brush like ordinary paint. It is composed of boracic acid, 5 lb. ; hydrochlorate of ammonia or sal-ammoniac, 15 lb. ; potash felspar, 5 lb. ; gelatine, 1·5 lb. ; size, 50 lb. ; water, 100 lb. ; to which is added a sufficient quantity of a suitable calcareous substance to give the composition sufficient body or consistency.

(3) A third composition, to be used for coarse canvas or sailcloth, cordage, straw, and wood, is applied by immersing the articles therein or by imbibition, and consists of boracic acid, 6 lb. ; hydrochlorate of ammonia or sal-ammoniac, 15 lb. ; borax (pure), 3 lb. ; water, 100 lb.

(4) A fourth composition, applicable to all kinds of paper, whether printed or not, including securities, books, etc., is formed of sulphate of ammonia (pure), 8 lb. ; boracic acid, 3 lb. ; borax, 1·7 lb. ; water, 100 lb.

The solution is to be placed in a vat heated to 122° F. (50° C.) at the end of the paper-making machine, and the paper as it leaves the machine is passed through the solution in this vat, so as to be completely impregnated therewith, after which it is dried upon a warm cylinder and then wound on a reel. If the paper be in sheets or printed, it is simply immersed in the above heated solution, spread out to dry, and afterwards pressed to restore the glaze destroyed by the moisture. The above compositions ensure a degree of incombustibility without precedent as regards the preservation of the materials to which they are applied. The proportions of the several ingredients are given as examples only, and may be varied as found necessary in practice.

(5) The 'Manufacturers' Review' translates from Hager the following directions for preparing a starch paste, impregnation with which renders a fabric incombustible : 10 lb. calcined and pulverised bones are treated with 50 lb. hot water, to which 6 lb. concentrated sulphuric acid are gradually added. The mixture is well stirred, and left to stand 2 days in a warm spot, being stirred from time to time ; 100 lb. distilled water are then added, and the liquid filtered. 5 lb. sulphate of magnesia (Epsom salts) are dissolved in 15 lb. distilled water, the solution is added to the first, and caustic ammonia is added till the liquid smells of it. The precipitate is thrown on a linen filter, pressed, dried in a moderately warm place, and rubbed to a very fine powder. Of this powder, 2 lb. are mixed with exactly 1 lb. tungstate of soda, 6 lb. wheat starch, and a little indigo blue to impart a bluish tint to the powder. In order to use this powder, it is stirred up with about twice its weight of cold water, and enough hot water is then added to produce a gelatinous liquid, in which the fabrics that are to be rendered incombustible are steeped.

(6) An old recipe for rendering cotton goods uninflammable is to add to the starch-size 15 lb. borax for every 1000 lb. size.

(7) To render ladies' clothing uninflammable it has been proposed that the materials should be sized with starch containing ammonia sulphate, a mixture of phosphoric and boracic acid, or in some cases tungstate of soda. Some experiments of Professor Gintl led him to recommend ammonia alum and hyposulphite of soda, both of them very cheap, as suitable substances for the purpose. ('Neue Gewerbe Zeitung.')

(8) The Abbé Maurau proposed to render textile fabrics of various kinds uninflammable, without affecting their colour, suppleness, strength, or wearing qualities, by treating them with a preparation of borax, sulphate of soda, and boracic acid, combined in suitable proportions. ('Revue Indust.')

(9) Tremaux stated that a more or less concentrated solution of sulphate of potassium and alum applied to textile fabrics prevents them from flaming (not from burning without flame), when a light is applied to them, and is in this respect as good a preservative as is to be met with. ('Comptes Rendus.')

(10) Gay-Lussac proposed to saturate tissues with ammonium carbonate. Chevalier used this salt in conjunction with borax. Fuchs recommends the use of sodium silicate (soluble glass). Versmann and Oppenheim employed ammonium phosphate alone, and with sal-ammoniac, ammonium sulphate, and sodium tungstate. Abel impregnated tissues with lead silicate, first soaking them in lead acetate, and then immersing in a solution of sodium silicate, and rinsing. The following solutions have been successfully applied for rendering tissues incombustible: (*a*) A mixture of sodium tungstate solution of 25° Tw. and 3 per cent. sodium phosphate; (*b*) 6 lb. alum, 2 lb. borax, 1 lb. sodium tungstate, 1 lb. dextrine dissolved in soap water; (*c*) 5 lb. alum, 5 lb. ammonium phosphate, 100 lb. water; (*d*) 3 lb. borax, 2½ lb. Epsom salts, 20 lb. water; (*e*) 8 lb. ammonium sulphate, 2½ lb. ammonium carbonate, 3 lb. boracic acid, 2 lb. borax, 2 lb. starch, 100 lb. water. ('Indust Blät.')

(11) Hosemann takes a solution of calcium chloride at 22° to 49° Tw., or in its place, aluminium or magnesium chlorides. He adds hydrochloric acid in the proportion of 1 lb. acid to 75 or 100 lb. of the solution, and stirs into the liquid 10 to 30 lb. potato starch. The liquid is heated to boiling, and 5 lb. steatite, previously stirred up in 1 gal. water, is added. While continuing the heating and agitation there are added 1 lb. ammonia sulphate dissolved in ½ gal. water, 3 lb. potash silicate dissolved in 30 lb. water, and lastly 5 lb. soda or lime bisulphite. The stirring and heating are maintained for ½ hour after the addition of all the materials. Thus is formed a whitish gelatinous mass, which may be used like starch or dressing. Articles saturated or coated with this mixture are uninflammable. A more simple composition may be obtained by adding potato starch to a solution of calcium chloride at 49° Tw., and heating to 167° F. (75° C.); having well stirred and continued to heat, 1 or 2 per cent. of soluble silicate of potash is added, and the liquid, which is alkaline, is neutralised by addition of an acid or acid salt. ('Mon. Prod. Chim.')

(12) Protochloride of manganese, 33 per cent.; phosphoric acid, 20 per cent.; boric acid or borax, 10 per cent.; chloride of magnesium, 12 per cent.; chloride of ammonium or sulphate of magnesia, 25 per cent. The materials are immersed for 6–8 hours in this solution at the temperature of ebullition. They quickly become impregnated with double salts, insoluble in water, and the incrustations that are formed effectually protect the materials treated against fire. When exposed to a quick fire, they carbonise, but produce no flame. (Prof. Winckelman.)

(13) One formula is to dissolve three parts by weight of borax with 2½ parts of sulphate of magnesia in 20 parts of

water. The fibres of the fabrics soaked in this solution become coated with a thin film of borate of magnesia which is insoluble in hot or cold water and well resists fire. Another preparation is a mixture of 1 part of sulphate of ammonia with 2 parts of sulphate of lime. A double sulphate results, which has the property of resisting fire, and of yielding, when brought to a high heat, volatile ammonia, which tends to smother flame.

(14) *Curtains, to Render Fireproof.* In 40 parts of warm water mix and dissolve 8 parts borax and 6 parts magnesium sulphate. Rinse or coat the fabric with this mixture.

(15) *Clothes, Fireproof Wash for.*—4 parts borax and 3 parts Epsom salts, mixed with 3 or 4 parts warm water to 1 part of the combined substances, is an excellent fireproof wash for clothes. It should be used immediately after preparation.

Incombustible Paste Boards and Plates.—By the employment of asbestos Nagel has produced an entirely incombustible paste-board in the following manner: A thin paste is made from 200 parts of oxide of zinc and 100 parts pulverised asbestos; this is spread out upon a metallic web. The mass is rolled, and after drying the plate is saturated with a strong solution of chloride of zinc, after which it is passed through the rollers a second time. By this treatment oxychloride of zinc is produced. The moisture causes the formation of a little rust upon the iron wire, by reason of which the substance adheres firmly. The plate is again dried and another time saturated with chloride of zinc; the whole is left in this state so that oxychloride may form, after which the plate is immersed in water for one or two days, whereby all the acid is removed. The plate is then washed and thereby receives its desired flexibility. Such plates, manufactured in this manner, will absorb water, but may be made impermeable by saturating them with a silicate and caseine.

These plates may also be prepared in another manner. Nagel has, for instance, replaced the chloride of zinc by other metallic chlorides and sulphate of alumina. In place of the oxide of zinc, magnesia, lime and gypsum may be used. For the covering of roofs, plates of the last-named material have been made impermeable by an addition of soap, whereby an insoluble combination of the fatty acids with lime and alumina. Plates prepared according to Nagel's formula will protect wood against danger of injury by fire, as was proved by the following experiment: A box 2·36 in. long, 1·58 in. broad and 1·18 in. high, and only 0·20 in. thick made of plates of this kind, was placed for 5 minutes between the flames of two Bunsen burners without any damage; a paper enclosed within it had not even turned brown.

Asbestos is also a constituent of a coloured coating prepared by Wendt and Herad; its composition is as follows: Colour (oxide of lead, copper or manganese), 15 parts; linseed-oil, 12; silicate of soda, 50; asbestos, talc and kaolin, 15; water, 8.

Writing Materials.—(1) A really incombustible paper, without a fireproof ink would be a very valuable article in many businesses, and for many purposes of every-day life, but if it can be supplemented by a fireproof ink, its value will be enhanced tenfold. Halfpenny prepared his paper in the usual manner from a pulp consisting of vegetable fibre, asbestos, alum, and borax, in or about the following proportions: Vegetable fibre, 1 lb.; asbestos, 2 lb.; borax, $\frac{1}{10}$ lb.; and alum, $\frac{1}{5}$ lb. The vegetable fibres are minutely divided, and treated in the manner usual in the production of ordinary paper; the asbestos is also divided as much as possible, and the two are then intimately mixed with the alum and borax in a sufficient quantity of water to make a pulp of the requisite consistency, which is then made into paper by any of the well-known processes. The proportions given may be varied to suit the quality and nature of the desired product, and also to suit the different qualities of the raw materials. Thus the inventor says he has made incombustible paper in which the proportions of the ingredients varied from 50 to 70 parts of asbestos, and from 30 to 50 parts of flax or other vegetable fibre, with only 2½ per cent. each of alum and borax. He proposes to use in some cases silicate of soda, in order to ensure hardness and coherence in the substance of the paper after it has been acted upon by fire. In order to obtain a paper of great strength and flexibility, the sheets may be made of linen or other woven fabric, and coated on both sides with the incombustible paper. The fireproof ink for use in writing or printing on the incombustible paper is made of the following substances: Graphite, 22 dr.; copal or other resinous gum, 12 gr.; sulphate of iron, 2 dr.; tincture of nutgalls, 2 dr.; and sulphate of indigo, 8 dr. These materials are mixed together and boiled in water, the graphite of course being reduced to an impalpable powder. This ink, which besides being fireproof is said to be insoluble in water, is black under ordinary circumstances; but when coloured inks are desired, the graphite is replaced by an earthy or mineral pigment of the desired colour.

(2) Fireproof paper was prepared by L. Frobeen by bleaching choice asbestos fibres with sulphurous acid, and adding 5 per cent. of ground wood-fibre with borax or glue-water, and worked into paper; it can be nicely smoothed, and is said to resist a white glow heat.

(3) The 'Chemiker Zeitung' gives the following modes of preparing incombustible writing and printing paper which appear worth attention: The best asbestos is treated with a preparation of permanganate of potash and then with sulphuric acid; 95 per cent. of this asbestos is mixed with 5 per cent. of wood-pulp in water containing borax and glue. A fireproof writing-ink is made by mixing Indian ink and gum with chloride of platinum and oil of lavender; for printing-ink lampblack and varnish are to be substituted.

(4) Paper made of pure asbestos resists a high temperature without material alteration. An ammoniacal solution of nitrate of silver, coloured with a little Indian ink, will preserve a legible copy when written with on the asbestos paper mentioned above, and subjected to strong heat.

(5) A free-flowing ink for writing on fireproof paper with an ordinary metallic pen may be obtained by using 5 parts dry chloride of platinum with 15 of oil of lavender, 15 of Chinese ink, and 1 of gum-arabic, adding thereto 64 of water. When the paper is ignited after being written upon with this ink, the platinum ingredient causes the writing to appear transparent, and, as a consequence, it is claimed that such writing as has become black or illegible will become readily legible again during the process of heating the paper. Colours for painting may also be made fireproof by mixing commercial metallic colours with the chloride of platinum and painters' varnish, adding an ordinary aquarelle pigment to strengthen the "covering power" of the colour. These fireproof paints or colours can be easily used in the same manner as the common water colours, and it is claimed they will resist the destructive influence of great heat quite as successfully as the fireproof printing and writing inks just referred to.

Extinguishing Compounds.—(1) 8 lb. carbonate of soda, 4 lb. alum, 3 lb. borax, 1 lb. carbonate of potash, and 24 lb. silicate of soda solution are mixed together; 1½ lb. of this mixture is added to each gal. of water when required for use. The object is to cover everything with a fireproof film or deposit.

(2) A committee of the Polytechnic Society of Munich issued a report on the means to be adopted for extinguishing burning petroleum. This states that since concentrated water of ammonia evolves a great amount of gas when heated, and this gas is unable to sustain the combustion of any

substance, it may be asserted that petroleum will not continue to burn even in a room filled with atmospheric air wherein a considerable proportion of ammonia gas is present. The place where the petroleum is stored must be broken up into compartments, so as to limit the bulk. The ammonia water must contain at least 10 per cent. of the gas. The proposed method of employing the agent is to keep a bottle full of it on each cask; the bottle and its contents would remain intact till fire caused the destruction of the one and the liberation of the other, so that there would be no loss except when needed.

(3) The now well-known *extincteur* introduced by Sinclair is a vessel filled with water charged with carbonic acid gas under great pressure.

(4) Foster introduced an *extincteur* in the form of a portable pump, which can draw a continuous water supply from any source, and saturate it with carbonic acid under pressure before emitting it in a jet.

(5) The carbonic acid is produced by decomposing a carbonate by an acid. If sulphuric acid be poured on a solution of soda carbonate, violent effervescence takes place, because the latter consists of carbonic acid gas combined with sodium oxide; the stronger acid (sulphuric) displaces the weaker, and itself combines with the sodium oxide to form soda sulphate, setting free the carbonic acid in a gaseous form. If this occurs in a close vessel, the carbonic acid accumulates with increasing pressure. In *extincteurs*, different means are adopted for liberating the sulphuric acid when action is to take place. In Sinclair's, a strong metallic vessel is nearly filled with soda carbonate solution, the acid being kept in a stoppered bottle in the midst of the solution. For use, the bottle is broken, with consequent liberation of the acid and generation of the gas, which is let out by a tap and tube. In Merryweather's, the acid is kept in a bottle with a loosely-fitting stopper, and for use, the whole apparatus is momentarily inverted, thus pouring the acid into the solution; in this way, fragments of glass from the bottle are avoided. In Shand and Mason's, the acid bottle in broken by a weight falling upon it, and provision is made for straining back broken glass from the outlet pipe. The Babcock extinguisher has a solution of bicarbonate of soda in water, and a suitable quantity of sulphuric acid in a lead flask. To cause the apparatus to act, the lead flask is turned over by a handle, which precipitates the acid into the soda solution. Carbonic acid is at once generated in large enough volume to cause a pressure that will discharge the whole contents through the nozzle. The quantities are acid 5 parts, soda 6 parts, by weight.

(6) Dumas discovered that water saturated with alum has superior value in extinguishing fires—a value supposed to be due to the coating it gives to objects wet with it, which prevents contact with the oxygen of the air, and thus diminishes the rapidity of the combustion.

(7) A solution of pearlash in water, thrown upon a fire, extinguishes it instantly; the proportion is 4 oz., dissolved in hot water, and then poured into a bucket of common water.

(8) *Fire Extinguishing Fluids.*—(1) Make a solution of 4 parts of crude calcium-chloride, 1 part salt, and 15 parts water. This can be kept in a barrel and is applied by a hand-pump. (2) Vienna.—4 parts ammonium sulphate, 1 part ferrous sulphate (copperas), dissolved in 25 parts of water. (3) Munich.—Common salt, 43 per cent.; alum, 19·5; Glauber's salt, 5; soda, 3·5; water-glass, 6·6; water, 22·3.

(9) *Fire Extinguishing Powder.*—3 parts bicarbonate soda, 1 Glauber's salts, 4 parts common salt, 1 part calcium chloride, 1 part sodium silicate.

(10) *Hand Grenade Charging Material.*—The grenades are thin glass bottles containing a solution of salammoniac or borax with calcium chloride in water.

(11) *Extinguishing Benzene and Petroleum Fires.* — (*a*) The use of ammonia for this purpose was proposed by a committee of the Polytechnic Society at Munich. (*b*) A much cheaper and more easily accessible extinguisher is ordinary ammoniacal gas-liquor of 5°–6° Tw. This was tried with the greatest success to extinguish a fire of a most formidable kind which suddenly broke out in a tar distillery. The heat of the fire causes a large disengagement of carbon dioxide and sulphuretted hydrogen, besides ammoniacal gas and steam. The use of gas-liquor (to be well settled and stored in closed boilers, with suitable piping and forcing power, etc.) has been strongly recommended for extinguishing fires in cotton mills. ('Jl. Soc. Chem. Ind.')

(12) Never try to extinguish a kerosene fire with water. Smother the flames with blankets or rugs.

Extinguishing Chimney Fires.—Reduce the draught up the chimney as much as possible, by closing doors and windows; then put some handful of common fine salt on the fire, and place a sheet of iron or a stout board in front of the fireplace to stop the ingress of air. Burning salt produces muriatic acid gas which is a good extinguisher of fire.

FIREWORKS.

(*See also* EXPLOSIVES, ETC.)

THERE are a few important rules of general application that may first be referred to, as they have a bearing on obtaining successful results, without risk. The first is that the various ingredients, when it is stated that they must be in fine powder, must be practically as fine as flour, and for amateurs, it is best to buy them in this condition rather than attempt to reduce them by pestle and mortar or grinding. Should anything require to be reduced to powder care must be observed to ascertain if it is a substance that can inflame or explode by heavy friction. Coloured fire or star compositions, many of them, are liable to this, potassium chlorate, also sulphur being always risky substances. Even the friction between the stopper and neck of a glass bottle has been known to cause accidents. It is quite possible to avoid friction between hard stones, metals, or such substances, and it should be made a rule never to let it occur. With such a substance as charcoal it does not matter of course, but there are few substances which may be considered always safe under such conditions, therefore let the manufacturers of the various substances produce them in powdered form. Another detail is as to mixing. Let this be done thoroughly well or that common event with amateur fireworks, a miss-fire or partial-firing, may be frequently expected.

The three principal materials of the art of pyrotechny are nitre, sulphur, and charcoal, with filings of iron, steel, copper and zinc, and rosin, camphor, lycopodium, etc. Gunpowder is used either in grain, half crushed or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a coarse file and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a very brilliant fire, with wavy radiations. Copper filings give a greenish tint to flame; those of zinc, a fine blue colour; the sulphide of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire, as well as colophony and common salt, but the last must be very dry. Lampblack produces a very red colour with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand, or glistening mica, communicates to fireworks golden radiations. Verdigris imparts a pale green; sulphate of copper and sal ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoin and storax are used also on account of their agreeable odour. Lycopodium burns with a rose colour and a magnificent flame.

Iron tools must never be used in making fireworks of any kind as they are liable to throw out sparks when striking against a hard stony substance, besides which the sulphur used would injure the iron. Wood, brass or copper tools may be used.

Rockets.—Of all fireworks, rockets are among the most effective. The ingredients, for these, the apparatus employed, and the detail of the manufacture of them may be considered the foundation of all fireworks, and to make them well involves the same principles, and requires the same caution, as making all others.

Sizes.—The size of rockets is indicated by ounces or pounds; thus we say, an eight-ounce rocket, a pound rocket, and so on; by this expression it is not meant that the rockets weigh so much as their name indicates but that the bore or cavity will just suffer a leaden bullet of that weight to pass down them. For example a pound rocket will admit a leaden bullet that weighs a pound. Rockets may be made of any size from 1 oz. up to 50 or more pounds.

Rockets are generally given numbers for sizes, No. 1 to 6, these being ½ oz., ⅜ in. bore; 1 oz., ½ in. bore; 2 oz., ⅝ in.; 4 oz., ¾ in.; 8 oz., 1 in.; 1 lb., 1½ in.

Cases or Cartridges.—These may be made of any kind of stiff thick paper, either cartridge paper, brown paper, or what is equally good and much cheaper, namely, common bag-cap paper. To roll up the cases you must have a smooth round ruler, or, as it is called, a former, usually brass tube, exactly the size of the cavity of the rocket.

Its length for the sizes just given would be about 9 in., 12 in., 16 in., 16 in., 16 in., 18 in. The amateur will, however, do well to confine himself to about the 2-oz. rocket to begin with. To prepare the case lay a sheet of the paper upon a slab of slate, marble or glass, and paste 4 or 5 in. along the end of it, leaving the rest of the sheet of paper without paste; then roll it smoothly over the former, dry end first, until the whole is rolled up, when of course the paste will stick, and a thin case will be formed. Keep rolling it along the slab with the hands, in the same way as a rolling-pin is used, for two or three minutes, until the various folds of the paper set close and tight to each other; then put on another sheet in the same way, and so on, till the case is thick enough. This is known by the measurement across it. If the former, without the case, measures five parts, when the case is upon it they must measure together eight parts. That is, the paper must be rolled on till it forms a case, the thickness of the sides of which are a trifle more than one-third of the thickness of the former. The length of the rocket-case, and consequently the width that the sheets of brown paper are to be cut before pasting varies with the size of the rockets; in small rockets the length of the case may be six times the diameter, in larger rockets four or five times is sufficient. When the case has proceeded thus far it is to be "choked" while yet damp, that is, to be contracted in diameter near one end, and for this purpose a simple contrivance is requisite, called a choking cord, and also the former is made with a hole drilled at one end, and a second joint made to fit on by means of a wire projecting at one end of it, and which fits into the hole of the former, Fig. 167. To choke the case, draw the former partly out, until you can see about 1 in. of the inner cavity of the case, then put on the second joint (the wire of which fits into the hole of the former), and pass this on until its end is about ½ in. within the case, leaving a space of about ½ in. between the two joints occupied by the wire alone. Then going to an apparatus similar to that shown in Fig. 168, turn the cord once round the case where the cavity is, put the foot upon the treadle, which tightens the cord and squeezes the paper case at the point required. That it may squeeze it equally and neatly on all sides, the case should be held in the hands and moved up and down upon the cord until the operator sees that it is sufficiently and properly compressed. Let it be observed that although the choking apparatus used by the firework maker is represented and abovealluded to, yet to the amateur it is by no means necessary. What will do quite as well is a thin cord, fastened at one end to a staple in the wall, and by the other tied round the waist of the operator; as he may lean back, of course the cord would be tightened, and the desired purpose accomplished. When the case is sufficiently compressed, it is tied with two or three turns of strong string. The case is now complete, except that the part of it where it is choked is perhaps rather rough and uneven inside; this must be compressed down, for much of the effect of the rocket will depend upon the perfect regularity on this part, as it is through the hole left by the wire in the middle of the choke that the fire is afterwards to issue. To compress this part properly a mould is necessary.

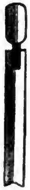

FIG. 167.

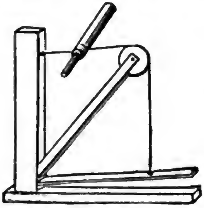

FIG. 168.

The Rocket Mould is represented in Fig. 169. It consists of a solid foot of wood; upon the centre of this stands a short cylinder about ½ in. high, and exactly of the size of the mould, to be placed over it, as afterwards described; this short cylinder has a shoulder above, and terminates in a round top. Out of the middle of the top is a tapering thick brass wire, projecting some inches upwards, as is seen in Fig. 170. The whole is so arranged, that when one of the newly-made cases is put upon the wire and forced down, the wire fills up the choke-hole, the round top fits into the small parts of the case below the choke, the shoulder of the cylinder bears the extreme end of the case, and the short cylinder agrees in size with the outsides of the case. There fits over this (case and all) a strong wooden or metal tube; so that it is seen that there is no cavity anywhere, except the inside of the rocket case, and even in this a thick wire runs up to nearly the top of that part of the case where the composition is rammed, or nearly ⅔ of the whole case from the choke upwards. The wire above mentioned is called

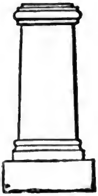

FIG. 169.

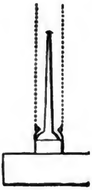

FIG. 170.

the piercer. All rockets must be placed in the mould to be filled, as well as to smooth and consolidate the part choked. With the mould are used rammers, Fig. 171, formed of hard wood, of the shape of a pop-gun stick ; these rammers being rather less than the diameter of the cavity, and having a hole bored up their centre, in order to admit the piercer. It is evident that there must be a complete mould, piercer, and one or more rammers for every size rocket. If it is desired to ornament it in any way, or cover it with white paper, this must be done before choking.

FIG. 171.

Charging.—The next process after drying the cases is to charge them with the requisite composition. Put the cases in the mould with the piercer in it, and put enough composition in to fill about 1 in. of the case ; then, taking the rammer, ram it down with three or four strong blows with a mallet. Then put in the same quantity of composition again, and ram that down in the same manner, and so on till the case is filled to the top of the piercer and one diameter above it. Then separate some of the central folds of the paper which it has been observed are not parted, and turn them down upon the composition, ramming them down hard upon it, or, what will do as well, put in a piece of paper as wadding. When this is rammed down, and firm, bore with a brass bradawl three or four holes through it. These holes serve to make the requisite communication between two parts of the rocket. Or, having charged the case, take some common potters' clay in dry powder, and ram it down hard upon the top of the composition, then bore a hole through it about $\frac{3}{16}$ in. diameter, which will allow of the necessary connection between the rammed composition and the stars in the head or pot of the rocket.

Priming.—The rocket is now supposed to be closed at one end. It only requires to be primed at the other end, and that, it will be observed, is the end which was choked, which is still open, and which has a hole passing up it which the piercer occupied. To prime it, fill up the hole with loose gunpowder made into a stiff paste with very weak gum water, and paste a piece of touch-paper over it.

Another method of priming is to use a piece of quick-match (described further on) and insert it as Fig. 172. The blue paper in such a case need not be touch-paper.

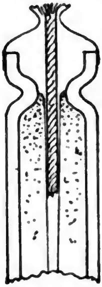
FIG. 172.

Pot or Head.—The rocket being then charged, the head or pot must be fixed. The pot is a paper case made upon a wooden former turned cylindrical, about 4 inches in length, and a shade larger in diameter than the exterior of the rocket case. Take some thick brown paper, and cut it in strips large enough to go twice round the former ; paste and roll as for the case, then pinch one end, and a cylinder of paper will be thus made which should fit nicely over the clay end of the rocket. There should now be fixed upon the pinched end a conical cap, made upon a former of conical shape like Fig. 173. Fig. 174 shows the completed pot and conical cap

FIG. 173.

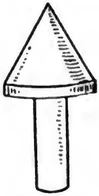
FIG. 174.

ready to receive the stars. The conical cap by cleaving the air assists the rocket in rising into it.

Loading.—Loading the pots with stars is all that now remains to be done to complete the rocket. A $\frac{1}{4}$-lb. rocket should carry about 1 oz. of stars. Weigh out the proper quantity of stars and mix them with meal-powder, 5 parts to 1 part fine charcoal; fill up the pot, and glue it securely over the clay or upper end of the rocket case.

Sticks.—Next fasten the stick to the rocket by two strings, as seen in any of the Figures 175 to 179, the sticks being previously prepared of proper length and size, as follows: The smaller ones are easily and best made of those laths called by bricklayers double laths, and the larger ones pantile laths; but any slip of deal, white-wood or pine, will answer the purpose. 2 lb. rockets require sticks 9 ft. long, 1 in. square at top, and rather more than $\frac{1}{2}$ in. square at bottom. 1-lb. rocket sticks are 6 ft. 6 in. long, $\frac{5}{8}$ in. square at top and $\frac{1}{2}$ in. at bottom. 8-oz. rocket-sticks are 5 ft. 6 in. long, $\frac{1}{2}$ in. square at top, and $\frac{3}{8}$ in. at bottom. 4-oz. rocket sticks are 4 ft. 6 in. long, $\frac{1}{2}$ in. by $\frac{3}{8}$ in. at top, and $\frac{1}{4}$ in. square at bottom. 2-oz. rocket sticks are 3 ft. 6 in. long, $\frac{5}{16}$ in. at top, $\frac{1}{4}$ in. at bottom. 1-oz. rocket sticks are 3 ft. long, by $\frac{1}{4}$ in. square, and so on for other various sizes. The weight and the length of the stick must be such, that when tied on, the rocket shall balance on the finger, at a point about 1 in. from the part choked.

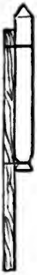
FIG. 175.

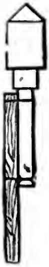
FIG. 176.

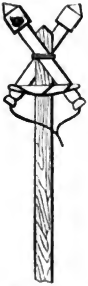
FIG. 177.

Compositions. — The brilliancy of the rocket depends upon the composition in the cases, and great care is required in the mixture of the ingredients, which should be well dried and carefully sifted through a hair sieve before mixing. For a $\frac{1}{4}$-lb. rocket, to 12 oz. of saltpetre add 6 of charcoal and 4 of sulphur; or for signal rockets the proportions are: Saltpetre, 4 lb.; dogwood charcoal, 1 lb. 12 oz.; sublimed sulphur, 1 lb. Powder separately, and mix with the hand or a wooden spoon. Saltpetre increases the rapidity of the fire, whilst sulphur retards it, and the charcoal emits those volumes of sparks which form the golden train of an ascending rocket.

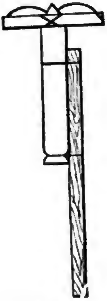
FIG. 178.

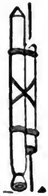
FIG. 179.

This composition, it will be noticed, is without gunpowder. If it is desired to add powder, as is the common practice, a good composition is saltpetre, 1 lb.; fine charcoal. $\frac{1}{2}$ lb.; meal-powder, 3 oz.; sulphur, $\frac{1}{4}$ lb. These quantities would be just about correct to fill two $\frac{1}{2}$-lb. rockets. The composition is usually put in dry, but to avoid dust, it can be just slightly moistened with methylated spirit, if desired.

Pyrotechnic and Rocket Stars.—The stars that are used as decorations to the different species of fireworks are of various kinds, sizes, and shapes, according to the purpose for which they are intended.

The ordinary rocket stars, which are called "brilliant" or "bright," are made in small cubes. Their composition is moistened with gum water, and while moist flattened to the thickness required. It is then scored or cut across with a knife, and allowed to dry. When dry, it can be easily broken up into cubes at the places where it was divided by the knife. Tailed stars are also made in the same way and of the same size.

Roman-candle stars are small cylinders of composition made of a size proportioned to that of the case out of which they are to be thrown.

Coloured rocket stars are made by driving the coloured composition, slightly moistened, into small cases, which go under the name of pill-box cases. If the star is to consist of one colour only, these pill-boxes are open at both ends, and a piece of quickmatch is placed between the composition and the inside of the pill-box, and allowed to project about ½ in. beyond each end of it. When fired, these stars burn at both ends at the same time, and so produce a great amount of fire in proportion to their size.

If it is required to make stars consisting of more than one colour (in which case they are called "changeable stars") the pill-boxes are left open at one end only. The composition is thus prevented from burning at more than one of its surfaces at a time. These stars generally contain two colours; the pill-boxes are half filled with one coloured composition and the remaining space is filled with another. These changeable stars burn much longer than the others, and therefore produce a more beautiful effect; but being larger they require to be used in larger rockets, the ½ lb. size being the smallest that is adapted for this purpose.

There is another and exceedingly beautiful decoration for rocket-heads which is called golden rain. This is by no means a difficult thing to make. Some small paper cases are made about 2 in. long and of the size of goosequills; these are filled with a sparkling composition and primed with wetted gunpowder. They are placed, mouth downwards, in the head of the rocket, and arranged in such a manner that they may all be ignited. At the bursting of the rocket, they will describe a series of beautiful ringlets of sparkling fire.

Common Brilliant Stars.—Nitre, 16 parts; sulphur, 8; sulphate of antimony, 4; meal-powder, 3. Let all the ingredients be in as fine a powder as possible; and having carefully weighed out the quantities, mix them thoroughly. Next, take some weak gum water made by dissolving 2 oz. of gum-arabic in a pint of warm water. Spread the star composition upon a piece of zinc plate or slate, and add to it a little of the gum water at a time, taking care to stir the composition about well till all the moisture is equally diffused. It is not necessary that this composition should be made wet, but only something like brown sugar in moistness, so that it will bind well when pressed together. When this is sufficiently done, roll or press the composition into a flat shape like a thick pancake, and make it as square as possible. Its thickness should be about ¼ in. Take a blunt knife spatula, and with it score the composition across both ways, so that it is divided into a number of little cubes.

Tailed Stars.—These stars are not moistened with plain gum water, but with a mixture of gum water and linseed-oil. The gum water should be of the strength given above, and should be made quite hot by placing the bottle which contains it in a jug of boiling water. When it is sufficiently hot, to every 8 oz. of gum water add 1 oz. of linseed-oil. Shake the bottle till these are thoroughly mixed, and no oil can be seen. Use the moistening fluid, while hot, in the same manner as directed above for brilliant stars. The following is the composition for tailed stars: Nitre, 16 parts; meal-powder, 12; antimony sulphide, 8; fine charcoal, 4½; sulphur, 4.

Coloured Stars.—These require considerable care in their preparation, the beauty of their performance depending entirely upon the uniform fineness, the intimate union, and the dryness of their ingredients. The various preparations which enter into their composition should always be kept ready for use in fine dry powder, preserved in well-corked or stoppered bottles. The pill-boxes for coloured stars are made in the following manner: Procure a piece of straight iron rod, 12 in. long, and ⅜ to ½ in. in size; the usual size for this former is about $\frac{7}{16}$ in. Now cut some cartridge paper into strips about 8 in. wide, and 9 to 10 in. long; paste these strips all over, and roll them round the iron rod closely and neatly. When this is done, remove the case thus formed from the rod without tearing or breaking it, and set it aside to dry. When dry it will be very hard and stiff. It can then be cut, by means of a very sharp knife, into little lengths of ½ in. each. These lengths are the open pill-boxes, into which the composition is to be rammed for coloured rocket stars. In order to accomplish the filling of these cases with the least amount of trouble, procure a piece of stick, of a convenient length, and of such a size round that it will pass easily into the pill-boxes, and with a short groove cut in the side, sufficient to allow it to pass the quick-match without injuring it. Next take a small piece of quick-match, about 1½ in. long, and pass it through the pill-box in such a manner that it may project beyond each end about ½ in. The composition pressed with the stick into these boxes is always slightly moistened; and by this means, when once dry, will not be liable to be shaken out again. The fluid employed for moistening these coloured compositions is a solution of shellac in methylated spirit of wine. Care must be taken not to make these compositions *wet*. A very slight moistening is sufficient to make them bind well when pressed into their cases.

Crimson Stars.—(*a*) Chlorate of potash, 24 parts; nitrate of strontia, 32; calomel, 12; sulphur, 6; shellac in fine powder, 6; sulphide of copper, 2; fine charcoal, 2.

(*b*) Chlorate of potash, 12 parts; nitrate of strontia, 20; sulphur, 11; charcoal, 2; antimony, 2; mastic, 1.

(*c*) Nitrate of strontia, 72; sulphur, 20; gunpowder, 6; coal-dust, 2.

Rose-coloured Stars.—Chlorate of potash, 20 parts; carbonate of strontia, 8; calomel, 10; shellac, 2; sulphur, 3; fine charcoal, 1. The advantage of this composition is that it is not at all liable to suffer from damp in winter. The carbonate of strontia is a salt not absorbent of moisture like the nitrate, and is, moreover, always to be had in a state of fine powder.

Green Stars.—(*a*) Chlorate of potash, 20 parts; nitrate of baryta, 40; calomel, 10; sulphur, 8; shellac, 3; fine charcoal, 1; fused sulphide of copper, 1.

(*b*) Nitrate of baryta, 42 parts; realgar, 2; sulphur, 8; lampblack, 1.

(*c*) Chlorate of potash, 28 parts; nitrate of baryta, 12; sulphur, 15; mastic, 1.

Pale Rose-coloured Stars.—Nitrate of strontia, 8 parts; chlorate of potash, 4; sulphur, 3; sulphide of antimony, 2. Take especial care that the nitrate of strontia used in this formula is very dry.

Pale Green Stars.—Nitrate of baryta, 16 parts; chlorate of potash, 8; sulphur, 6; antimony, 3.

Yellow Stars.—(*a*) Chlorate of potash, 20 parts; bicarbonate of soda, 10; sulphur, 5; mastic, 1.

(*b*) Chlorate of potash, 30; dried soda, 12; sulphur, 8.

Golden Yellow Stars.—Chlorate of potash, 20 parts; nitrate of baryta, 30; oxalate of soda, 15; sulphur, 8; shellac, 4. If it is thought advisable to give the stars made from this formula a tailed appearance, add one part of fine charcoal. The composition is to be moistened with the shellac solution. The stars form a beautiful contrast with those of an intense blue.

Blue Stars.—(*a*) Chlorate of potash, 8 parts; sulphide of copper, 6; Chertier's copper, 5; sulphur, 4.

(*b*) Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1.

(*c*) Chlorate of potash, 16 parts; Chertier's copper, 12; calomel, 8; stearine, 2; sulphur, 2; shellac, 1. This gives a most intense blue.

(*d*) Chlorate of potash, 20 parts; carbonate of copper, 14; sulphur, 12; mastic, 1.

(*e*) Nitre, 12 parts; sulphide of antimony, 2; sulphur, 4; lampblack, 2. All these compositions should be moistened with gum water, and in (*c*) the stearine employed must be in fine powder.

Violet Stars.—Chlorate of potash, 9 parts; nitrate of strontia, 4; sulphur, 6; carbonate of copper, 1; calomel, 1; mastic, 1.

White Stars.—Saltpetre, 9 parts; sulphur, 3; antimony, 2.

To Prepare Chertier's Copper.—Take any quantity of common sulphate of copper, or blue vitriol, and dissolve it in as little water as possible; then take an equal quantity by weight of chlorate of potash and also dissolve in as little water as will hold it in solution. Mix these two solutions, and boil them gently over a clear fire until the moisture is nearly evaporated; then dry the green precipitate that remains by a gentle heat. When dry, treat it with strong liquor ammoniæ till it changes to a deep blue colour; then let it dry very gradually in a warm place. If this operation be properly performed you have a fine, very light blue powder, which is Chertier's copper.

To Prepare Nitrate of Strontia.—Procure a common earthenware pipkin, or a glazed iron frying-pan of a convenient size. Into this place nitrate of strontia in rough crystals; 1 or 2 lb. will be sufficient to prepare at a time. Place the vessel on a clear fire, but do not make it too hot. Now boil, or rather stew, the crystals in their own water of crystallisation. The heat will soon cause them to run into a thick pulpy mass. When in this state they must be constantly stirred, or upon the evaporation of the moisture they will resume a crystalline form. Continue then to stir it with a stick or flat piece of wood until the moisture is driven off by the heat, and the salt remains in the condition of a white dry sand. No unprepared strontia can be used for coloured stars or fires, and this operation is proper also for the preparation of the nitrate of baryta.

Golden Rain.—Golden rains are made in the following manner: Procure a piece of brass rod, the diameter of which is $\frac{3}{16}$ in., or rather less. The length of the former may be 6 to 8 in. Cut thin brown paper into short strips, about 2 in. wide, and long enough, when wrapped round the former, to make a case whose external diameter shall be $\frac{1}{4}$ in., or rather more. The former should have a small cup-shaped hollow cut in one of its ends, into which the paper may be turned, to form a closed end to the cases. Paste the strips of paper all over, and also rub some paste on the former; then roll the paper round the former, and draw it out so as to leave its cupped end $\frac{1}{4}$ in. inside one of the ends of the case. Pinch in the paper that projects beyond the former, and drive it down with a tap upon the pasting slab, so that the twisted end is pressed into the cup of the former. By this means a neat and secure end is obtained for the cases, which may be dipped afterwards into warm size or glue. If a little red-lead is mixed with this size, it will solidify much more rapidly. This dipping the ends of the cases into size should not be done until they are dry from the paste. For filling the cases a tin funnel is used that will exactly fit into the mouth of golden-rain cases.

The compositions employed for filling the cases are the following : (*a*) Meal-powder, 6 parts ; nitre, 1 ; fine charcoal, 2.

(*b*) Meal-powder, 8 parts ; fine charcoal, 3.

(*c*) Saltpetre, 1 lb. ; meal-powder, 4 oz. ; sulphur, 4 oz. ; brass dust, 1 oz. ; sawdust, 2¼ oz. ; glass dust, 6 dr.

When the case is charged, the funnel must be removed, and the space that was occupied by its nozzle filled with gunpowder or meal-powder, moistened with gum water. This will prevent the composition from being shaken out of the cases, and at the same time forms the best method of priming them. Take care that this paste is pressed well into the mouth of the cases, and fills them.

Silver Rain.—(*a*) Saltpetre, 4 oz. ; sulphur, meal-powder, and antimony, each 2 oz. ; sal prunella, ½ oz.

(*b*) Saltpetre, 8 oz. ; sulphur, 2 oz. ; charcoal, 4 oz.

(*c*) Saltpetre, 1 lb. ; antimony, 6 oz. ; sulphur, 4 oz.

(*d*) Saltpetre, 4 oz. ; sulphur, 1 oz. ; powder, 2 oz. ; steel dust, ¾ oz.

Used in similar cases and treated in the same way as *golden rain*.

Portfires.—The portfires used for firing rockets and fireworks are generally made in the following manner : The former for this purpose should be of brass, and not less than ¼ in. in diameter, and the wire for filling them not less than ⅛ in. Portfire cases are usually made very thin, but prepared in precisely the same manner as golden rains, and are also primed in the same way. The following are the compositions usually employed for portfires.

(*a*) Nitre, 6 parts ; sulphur, 2 ; meal-powder, 1.

(*b*) Saltpetre, 2 lb. ; sulphur, 3 lb. ; antimony, 1 lb.

(*c*) Saltpetre, 3½ lb. ; sulphur, 2½ lb. ; meal-powder, 1 lb. ; antimony, ½ lb. ; glass dust, 4 oz. ; brass dust, 1 oz.

Roman Candles.—In the manufacture of these fireworks, the following important points must be observed, namely, to have a composition to burn in the intervals between the stars, which will throw a jet of fire uniformly good throughout ; to have stars of tolerably rapid combustion, otherwise they will not be ignited before they are blown into the air . and to have the charges of powder for blowing the stars regulated to a great nicety. The former for the cases of a 2-oz. candle must be ⅝ in. in diameter, and 18 in. long. The cases may be made of brown or other paper as described with rocket cases and the process of making the cases is similar.

Composition for Roman Candles.—(*a*) Nitre, 18 parts ; sulphur, 6 ; fine charcoal, 7 ; meal-powder, 4.

(*b*) Nitre, 16 parts ; meal-powder, 8 ; fine charcoal, 6 ; sulphur, 6.

(*c*) Nitre, 16 parts ; meal-powder, 11 ; sulphur, 6 ; antimony, 4.

The second of these (*b*) is the one most employed.

Roman-Candle Stars.—The brilliant stars may be made of the same composition as that given for rocket stars of that kind. If, however, a whiter star is required, use the following : Nitre, 48 parts ; sulphur, 10 ; regulus of antimony, 8 ; realgar, 6 ; red-lead, 4 ; shellac, 1. Yellow Roman-candle stars may be made from the same formula as that given for yellow rocket stars. Green Roman-candle stars may be made from the formulas given for rocket stars ; but there is also another formula, which produces a rather deeper tint, but is hardly rapid enough in combustion for rocket stars. It is the following : Nitrate of baryta, 40 parts ; chlorate of potash, 20 ; calomel, 12 ; sulphur, 12 ; fine shellac, 4 ; fine charcoal, 1. The formulas for crimson, rose, blue, and purple Roman-candle stars are the same as given for rocket stars. In order to make the stars, moisten the compositions very slightly. The mould in which these stars are shaped is a brass tube, Fig. 180, of a size proportioned to the size of the

Roman-candle case, and is generally about 1/16 in. smaller in its inner diameter than the case. The drift with which the composition is pressed into the tube, is made of box-wood or metal, and fits easily into the tubular mould. At one of its ends is a brass wire point nearly ⅛ in. thick. Place the end having the point in the mould as far as it will go. It will leave a space at the end of the mould unoccupied by the drift. Press this empty end of the tube into the slightly-moistened composition until it is filled by it, so that the drift, being driven down upon the composition, will compress it into a firm cylindrical mass, into the centre of which the wire point projects. When the star is thus formed in the mould, the drift must be withdrawn, reversed, its long plain end inserted, and the star pushed out. The object of making the star hollow is that it may dry and harden perfectly in its centre, and also for the priming of the star, which is effected by placing a little piece of quick-match into the hole in the star, and allowing it to project about ¼ in. above. By this means even slowly-combustible stars are ignited, and almost every chance of failure is avoided. This priming, however, should not be done until the stars are to be put into the cases—at all events not till they are perfectly dry.

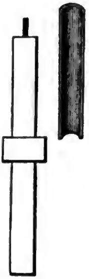

FIG. 180

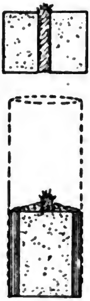

FIG. 181.

Fig. 181 shows, in section, a finished star with the quick-match in it. The match projects a little at one end, only this being the end which the burning composition comes to first. The projecting end becomes ignited, the fire passes by the match to the gunpowder beneath the star, and at the same time ignites the star. The explosion of the powder beneath the star and the ignition of the star are simultaneous, consequently the star is ejected immediately it lights. By an older method the star had to burn partially through, while it lay in the case, before the powder charge became ignited.

The next thing is to fill the case. Before filling it, introduce a little clay to the bottom of the case, thus forming a better and firmer bottom. This being done properly, put in the first charge of powder and on this the first star (the last one to be discharged). On the top of this put a charge of composition to fill about 1¼ in. space, putting it in in two lots, and pressing each down with a plain ended drift or rammer with the pressure of the hand only. On top of this put one thickness of touch paper, its purpose being to prevent the explosion of the charge of gunpowder, which will lie on it scattering the composition beneath. On this touch paper put the second charge of gunpowder then the star and on this composition, and another piece of touch paper. The last thing to go in the case is a charge of composition. A strip of touch-paper, twisted, is all that is needed to fire the candle, though with exhibition pieces a little meal-powder paste is pressed into the mouth of the case.

An important detail is that of pressing the composition in evenly, so that it burns at a uniform speed. It should be well pressed in, but not sufficient to injure the stars. A still more important detail relates to the charges of powder which send out the stars. These, correctly speaking, should vary with each star, being most with the first star to be ejected and least with the last one in the bottom of the case. For a 2-oz. candle the quantity of powder (ordinary sporting powder) will vary from 25 grains for the star nearest the mouth, the one to first leave the case, down to 4 or 5 grains for the one in the bottom of the case. With 6 stars, starting from the mouth, the quantities may be 20 grains, 8 grains, 7 grains, 6 grains, 5 grains, 4 grains. If a number of Roman candles are to be made, measures could be made by cutting down pill-boxes to take the exact quantities, the quantity being marked on each.

Touchpaper.—Obtain some thin blue paper—not so thin as tissue paper, but thinner than the ordinary blue paper used by storekeepers; brush or sponge this over with or dip it into a weak solution of saltpetre, and when well saturated dry for use. Touchpaper should be cut into slips, placed once round the mouth of the firework, and twisted into a point.

Quick-Match.—(*a*) Make a thick paste of gunpowder and hot water, with a small quantity of gum in it. Take about 4 strands of cotton, such as is sold in balls, and called wicking, steep this in the solution of nitre used for making touch-paper, and wring it as dry as possible; then rub it well in the gunpowder paste till it is thoroughly covered with it. One end of the cotton may be passed through a small funnel, whose mouth is not more than $\frac{1}{8}$ in. in width. By this means, if the whole length of the cotton is drawn through it, the superfluous paste will be removed, and the match will be of a nice round form. Hang it out of doors on a dry day, and when it is nearly dry coil it upon a tray or paper, and dust it over with meal-powder. In winter it will not be sufficiently dry for use under a week. When thoroughly dry it should be stiff and hard, and the less it is bent or doubled the better. To use this match for connecting the mouths of different fireworks, or "clothing" them as it is termed, make some long paper tubes round a wire "former" which has a diameter of not less than $\frac{3}{16}$ in. These pipes are threaded on the match, and have a piece cut away at their side wherever they are inserted into the mouth of a case, in order that the match may be laid bare and convey its fire to the priming of the cases.

(*b*) Quick-match is made of cotton lamp-wick thread, soaked for an hour or two in a mixture of gunpowder, $1\frac{1}{2}$ lb., and gum water, made by dissolving 2 oz. of gum-arabic in 1 pint of water, into which the gunpowder should be beaten up till dissolved. The cotton may be 3, 4, or more strands in thickness, and should be wound off out of the mixture, passed through a funnel pipe to make it even, and dried on a frame. It must be enclosed in paper tubes for use, as it will not burn with the necessary rapidity if not covered.

Another Method is by coating lamp-cotton as thickly as possible with meal-powder, rendered adhesive by mixture of thick gum-arabic, and covered by two strips of paper wound round it spirally, one over the other in opposite directions, the outer one being pasted to the inner.

Gerbes and Jets of Brilliant, Chinese, and Common Fires.—These are certainly among the most beautiful and effective pieces to be met with in the whole range of pyrotechny. They have one great advantage—that there is no limit to the modes of combination or arrangement in which these pieces may be effectively employed. By means of them any such things as the following can be made: Fountains of any size or design, cascades, brilliant suns, either fixed or revolving, bouquets of Chinese fire, spread eagle, trees of silver flowers, and a thousand other devices. Their compositions, to produce the desired effect, must be made as shortly as possible before it is intended to fire them, as iron and steel filings are a principal ingredient in their composition. Many attempts have been made to secure these metallic ingredients from corrosion. A coating of any kind is tolerably certain either to rob the spark which each particle of metal should produce of its brilliancy, or to render the composition during combustion very smoky, and so impair the intended effect. The most successful plan is the following: A weak solution of asphalt in naphtha is made, and the filings or borings are stirred about in this. When it is thought that they are thoroughly covered with it, the solution is poured off, and the filings are spread out upon paper to dry. But still the best way is to prepare the compositions as short a time as possible before they are to be fired. The cases should be made like rocket cases, and choked while wet, only it must be remembered that their aperture may be almost choked up, because when it has been reopened by the point over which they are loaded, it must not be more the ⅓ of the interior diameter of the case in size.

Red Chinese Fire.—(*a*) Meal-powder, 16 parts; nitre, 16; sulphur, 4; charcoal, 4; iron borings, 14.

(*b*) Meal-powder, 16 parts; sulphur, 3; charcoal, 3; iron borings, 7.

(*c*) Meal-powder, 8 parts; nitre, 16; sulphur, 3; charcoal, 3; iron borings, 8.

(*d*) Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 3; iron borings, 7.

White Chinese Fire.—(*a*) Meal-powder, 16 parts; nitre, 6; sulphur, 3; iron borings, 10.

(*b*) Meal-powder, 16 parts; nitre, 4; sulphur, 2; iron borings, 6.

(*c*) Meal-powder, 16 parts; iron borings, 5.

For filling the cases nipples of various sizes are employed, made preferably of metal. The case must now be pressed over the point of the nipple, Fig. 182, and by this means its aperture will be made of the proper size. It will be found very convenient to have a ring of iron fixed into your block, through which the case must be passed, which will steady it and keep it in a perpendicular position while being filled. Now drive in the composition, a ladleful at a time, and after putting in each ladleful give the drift twelve blows with the mallet. Fill the cases till there remains a space of 2 in. only unoccupied at the end. Into this end put a gun charge and a half of gunpowder. Then with a bradawl separate one or two of the inner folds of the paper of the case and turn these down on the top of the powder.

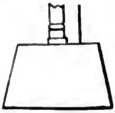

FIG. 182.

For filling in the ends of the cases: Melt in an earthen pipkin a mixture of 2 parts of common rosin, and 1 of wax. This may be poured into the ends of the cases upon the paper that has been turned down. It will harden in a few minutes, and will be found to ensure a good report from the powder. To prime these cases is an operation requiring some care, although it may be performed in a very simple manner. If the point of the nipple is not too long, all that is needed is to press into the mouth of the case some meal-powder paste; but if a cavity has been left in the composition, this must be filled up before priming, or the case will inevitably burst. It is an excellent plan to take for the first ladleful not any of the compositions for Chinese fire, but a ladleful of some slower fire containing no iron borings, such as a mixture consisting of nitre, 6 parts; sulphur, 1; charcoal, 1. These gerbes or jets are exhibited, when finished, by being attached to strong frames of wood or metal, arranged in such a manner as the exhibitor may wish, to produce any desired effect. The mouths of the cases are connected by means of leaders or quick-match.

Brilliant Fire.—The cases employed for brilliant fire need not be so large as those employed for Chinese fire, but observe the same rules in filling these cases.

(*a*) Meal-powder, 4 parts; bright steel filings, 1.

(*b*) Meal-powder, 16 parts; nitre, 8; sulphur, 3; fine charcoal, 3; bright steel filings, 10. Neither of these compositions should on any account be mixed before their preparation is absolutely necessary, for their whole beauty depends upon the brightness of the filings at the time of firing.

Common and Sparkling Fires.—(*a*) Meal-powder, 4 parts; charcoal, 1.

(*b*) Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 4.

(*c*) Meal-powder, 16 parts; very fine glass dust, 5.

(*d*) Meal-powder, 8 parts; very finely powdered porcelain, 3.

These fires can be arranged very effectively as stars, suns, etc. For instance, provide a circular disk of hard wood, 6 in. in diameter and 1 in. thick. Nail to this five spokes of wood at equal distances from one another, and 15 in. long. Nail also to the back of the central disk a strip of wood about 2 ft. long, 2 in. wide, and ¾ in. thick. By means of this you can screw the whole piece conveniently to your firing post. On each of the five spokes tie a case of brilliant fire, and connect the mouths of these with quick-match.

Lances. — Lances are used in making up devices, such as names, mottoes, wreaths, and so on. They consist of small cases, generally made about 3/16 in. in diameter, that is, round a piece of glass or brass rod or tube of that size; tubes are always best for these small formers. The cases are about 2 or 2½ in. long, with one end pinched or turned in. Two rounds of thin demy or double-crown white paper, pasted, will give sufficient thickness and substance for the case. The cases, when dry, are to be filled with either of the following compositions in the same way as golden rain:—

Composition for Lances. White.—(*a*) Nitre, 16 parts; sulphur, 8; meal-powder, 6.

(*b*) Nitre, 16 parts; sulphur, 4; meal-powder, 6.

(*c*) Nitre, 12 parts; sulphur, 4; sulphide of antimony, 3.

(*d*) Nitre, 72 parts; sulphur 18; regulus of antimony, 38; realgar, 1; shellac, 1.

(*e*) Nitre, 96 parts; sulphur, 24; regulus of antimony, 48; realgar, 6; shellac, 1.

These for the most part give a bluish white flame, and when employed in cases of the size mentioned above, burn slowly, and will last as long as this species of firework is required to last.

Yellow.—(*a*) Chlorate of potash, 72 parts; oxalate of soda, 60; stearine, 6; sulphur, 6.

(*b*) Chlorate of potash, 40 parts; oxalate of soda, 16; shellac, 8; stearine, 3.

Green.—(*a*) Chlorate of potash, 60 parts; nitrate of baryta, 41; calomel, 49; powdered sugar, 30; shellac, 1.

(*b*) Chlorate of potash, 63 parts; nitrate of baryta, 50; calomel, 50; sugar, 32; shellac, 1.

(*c*) Chlorate of baryta, 18 parts; calomel, 7; very fine shellac, 3.

(*d*) Chlorate of baryta, 24 parts; stearine, 3; very fine sugar, 1.

Red.—(*a*) Chlorate of potash, 13 parts; nitrate of strontia, 10; calomel, 8; shellac, 3; dextrine, 1; Chertier's copper, 1; fine charcoal, 1.

Rose-coloured.—Chlorate of potash, 24 parts; sulphur, 2; stearine, 3; oxalate of strontia, 4. This composition will remain good for any length of time.

Blue.—(*a*) Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1.

(*b*) Chlorate of potash, 32 parts; Chertier's copper, 12; calomel, 40; sugar, 25.

(*c*) Chlorate of potash, 6 parts; Chertier's copper, 1; calomel, 5; sugar, 4.

Violet.—Chlorate of potash, 26 parts; calomel, 24; carbonate of strontia, 4; Chertier's copper, 3; sugar, 14.

Lilac.—Chlorate of potash, 12 parts; prepared chalk, 4; sulphur, 5; calomel, 3; sulphide of copper, 10. Sugar for pyrotechnic compositions must be kept in a closely-corked or stoppered bottle. It should be reduced to powder in a very dry mortar, and then sifted through very fine muslin.

To exhibit lances, procure a board of sufficient size for the design, or make a wooden framework of the shape that is required. Sketch the design upon one side of the board, or, if larger than board will allow, make a plain rough framework describing the letters, When this is done, decide upon the distance at which to place the lances one from another. This distance is generally about 2 in., but no exact rule can be laid down, for much depends upon the kind of design, and upon its size. On the outlines of the sketch make little pencil circles wherever it is intended to place a lance; and, as far as it is possible, arrange that the lances shall be equidistant one from another. Now with a centre-bit, or, what is better, a pin-bit, bore a hole about ¼ in. deep where the circles are pencilled. These holes must be of such a size that the closed ends of the lances will fit easily into them. Get either some glue or some of the mixture of size and red-lead, and when it is liquid, dip into it the closed end of each of the lances. Enough of the mixture will adhere to the lances to allow of their being secured firmly in the holes that have been bored. In a very short time all will be hard and dry, and you will then have a series of lances projecting at right angles with your board or framework, each having its mouth primed, and all being the same length. The only thing that remains now to be done is to clothe these primed mouths with quick-match. This is by no means difficult, but requires a certain amount of patience. Take a length of match in its case, and, having exposed one end of the black match itself, put a small pin through it into the priming of one of the lances. This will fasten it down, and at the same time will ensure ignition. Then lead the quick-match on to the next lance, cutting away with scissors a piece of the under side of its case, to allow the match in passing to touch its priming. Put a pin through the match into the priming of this lance also, and so on till all are clothed. If more of the casing of the match has been cut away than is necessary, it will be well to paste small strips of paper wherever this has happened, as any exposure of the black match will endanger the piece, rendering it liable to ignition from the sparks of other fireworks.

Coloured Lights.—Their preparation is exceedingly simple. They are generally made in two sizes only; these are the 2-oz. and the 1-oz. sizes. The cases are made of cartridge or foolscap paper, and are about 2 in. long for the 2-oz. size and 1¾ in. for the 1 oz. sire. Used-up copy-books furnish excellent paper for making these coloured-light cases. Three or four rounds of the paper will give ample thickness for the case. The paper should be pasted all the way along the strips. When the cases are thoroughly dry, ram into the bottom of them some dry powdered clay; this will make a close end, and will also furnish an incombustible part by which the case may be tied or fastened to its place.

White, for Decoration.—(*a*) Nitre, 4 parts; sulphur, 1; sulphide of antimony, 1.

(*b*) Nitre, 4 parts; sulphur, 1; meal-powder, 1.

These will give the ordinary bluish light, and compositions made from them will remain good for any length of time.

Yellow may be made from the formulas given under the head of Lances.

Green.—Nitrate of baryta, 80 parts; chlorate of potash, 32; sulphur, 24; calomel, 16; fine charcoal, 3; shellac, 2.

Red.—(*a*) Chlorate of potash, 32 parts; nitrate of strontia, 48; calomel, 20; shellac, 1½; Chertier's copper, 4; fine charcoal, 1.

(*b*) Chlorate of potash, 84 parts; nitrate of strontia, 80; calomel, 51; dextrine, 22; shellac, 18; Chertier's copper, 4.

Purple.—(*a*) Chlorate of potash, 28 parts; Chertier's copper, 21; calomel, 13; shellac, 8; stearine, 1.

(*b*) Chlorate of potash, 40 parts;

calomel, 28; Chertier's copper, 28; dextrine, 10; stearine, 3.

(*c*) Chlorate of potash, 26 parts; Chertier's copper, 24; calomel, 14; shellac, 7.

Coloured Fires.—In the preparation of coloured fires the utmost care should be taken to have the component parts of the mixtures well triturated apart from each other, passed through fine sieves, and kept separately in stoppered bottles. They do not improve by keeping, and therefore should be used as soon as possible after mixing. The proper amount of each ingredient being parcelled out and placed on a sheet of glass or paper, the whole is carefully mixed with a light hand by means of a bone or wooden knife, a common paper knife for instance. Chlorate of potash must be treated with especial caution, as it is very liable to explosion from friction whilst in contact with combustible matter.

Blue.—(*a*) Sulphur, sulphate of potash, and ammonio-sulphate of copper, of each 15 parts; nitre, 27; chlorate of potash, 28. For theatrical illuminations.

(*b*) Metallic antimony, 1 part; sulphur, 2; nitre, 5.

(*c*) Sulphate of copper, 7 parts; sulphur, 25; chlorate of potash, 69.

Crimson.—Chlorate of potash, 4¼ parts; alder or willow charcoal, 5¾; sulphur, 22½; nitrate of strontia, 67½. For pots.

Green.—(*a*) Charcoal and sulphide of arsenic, of each, 1¾ part; sulphur, 10½; chlorate of potash, 23¼; nitrate of baryta, 62½.

(*b*) Nitrate of baryta, 77 parts; chlorate of potash, 8; fine charcoal, 3; sulphur, 13.

(*c*) Metallic arsenic, 2 parts; charcoal, 3; chlorate of potash, 5; sulphur, 13; nitrate of baryta, 77.

Lilac.—Black oxide of copper, 6 parts; dry chalk, 20; sulphur, 25; chlorate of potash, 49.

Purple.—(*a*) Sulphide of antimony, 2¾ parts; black oxide of copper, 10; sulphur and nitrate of potash, of each, 22¾; chlorate of potash, 42.

(*b*) Sulphur, 12 parts; black oxide of copper, 12; chlorate of potash, 30.

Red.—(*a*) Sulphur, sulphide of antimony, and nitre, of each, 1 part; dried nitrate of strontia, 5.

(*b*) Chlorate of potash, 20 parts; sulphur, 24; nitrate of strontia, 56.

(*c*) Coal-dust, 2 parts; gunpowder, 6; sulphur, 20; dried nitrate of strontia, 72.

(*d*) Nitrate of strontia, 37½ parts; flowers of sulphur, 10; charcoal, 1¼; powdered chlorate of potash, 5; black sulphide of antimony, 3⅛.

Violet.—Charcoal, 8 parts; sulphur, 10; metallic copper, 15; chlorate of potash, 30.

White.—(*a*) Nitre, 60 parts; sulphur, 20; black sulphide of antimony, 10; meal-powder, 6; powdered camphor, 4.

(*b*) Gunpowder, 12½ parts; zinc filings, 18; sulphur, 23; nitre, 46½.

(*c*) Charcoal, 1 part; sulphur, 24; nitre, 75.

Yellow.—(*a*) Sulphur, 16 parts; dried carbonate of soda, 23; chlorate of potash, 61.

(*b*) Charcoal, 6 parts; sulphur, 19½. For pans.

Pyrotechnic Mixtures:—

White Light.—Saltpetre, 8 parts; sulphur, 2; antimony, 2.

Red Light.—Nitrate of strontia, 20 parts; chlorate of potash, 5; sulphur, 6½; charcoal, 1.

Blue Light.—Chlorate of potash, 9 parts; sulphur, 3; carbonate of copper, 3.

Yellow Light.—Nitrate of soda, 24 parts; antimony, 8; sulphur, 6; charcoal, 1.

Green Light.—Nitrate of baryta, 20 parts; chlorate of potash, 18; sulphur, 10.

Violet Light.—Nitrate of strontia, 4 parts; chlorate of potash, 9; sulphur, 5; carbonate of copper, 1; calomel, 1.

Tourbillions.—The tourbillion is a species of firework very ingeniously contrived to represent a spiral column of fire. Its performance is of short duration, but while it lasts it produces a very striking effect. A tourbillion consists of a stout case filled with a strong sparkling composition, and closed very tightly at both ends. In this case are bored four holes, at which the fire is to find vent. Two of these holes are made underneath the case; from these the fire issues in a downward direction, and gives the piece the power of ascending perpendicularly. The outer two holes are made in opposite sides of the case near each end; the fire issuing from these causes the case to revolve in a horizontal direction while it is ascending. The cases are made as for rockets, and should be about 8 in. in length, and ¾ in. in their bore. Their external diameter will be found to be about 1⅛ in.

Plain.—Nitre, 8 parts; meal-powder, 16; sulphur, 4; charcoal, 4.

Brilliant.—Meal-powder, 16 parts; nitre, 8; sulphur, 3 to 4; fine charcoal, 3; steel filings, 6. Tourbillion cases are filled by means of an apparatus which consists of a block of wood, Figs. 183, 184, provided with a settle *n*, on which one end of the tourbillion case is placed, and over which the composition is rammed. There is a wooded mould for enclosing the case and supporting it tightly and firmly while the operation of ramming is being performed. This mould Q, Fig. 184, consists of a hollow cylinder of wood pierced throughout, and of such a size in its bore as will just admit the tourbillion case. The mould is divided longitudinally in halves, and these halves are kept together by means of iron rings O, which encircle the whole. P is a pin to pass through cylinder and settle to connect them. In order to fill the cases, squeeze one end of one of them over the projecting piece at the top of the settle. Fit on the two halves of the cylindrical mould, drive down the iron rings until they are tight, and put in the pin which secures the cylinder to the block and settle. First put into the tourbillion case as much clay as will, when rammed very hard, occupy ⅜ in. in the length of the case. The settle projects into the case about ⅛ in, and thus ½ in. at each end of the case is left for the purpose of ensuring a very firm ending, which cannot be blown out by the combustion of the composition. When the clay has been rammed in as tightly as possible, drive in the composition, a ladleful at a time, as uniformly as possible, until only ½ in. at the upper end of the case is unoccupied by it. Into this vacant space drive the same quantity of clay that was put into the lower end, and be sure that it is rammed in very firmly. When this is done, open your penknife, and lay its blade on the table, back downwards and edge upwards. Place the filled tourbillion case across the edge of the knife, and find the exact central point at which it balances on it, and mark that point by making a hole there with a small bradawl. Now, having found the centre of its balance, next mark the places at which the holes are to be made, and by far the best way is to use a shape made of zinc or tin, such as is shown, Fig. 185. This piece of sheet metal, when bent into the form of a trough of such a size as to fit tightly round the tourbillion case, will give the true position of the holes. In using it, put the filled tourbillion case into it, and make pencil marks through the holes that correspond to those drawn in the Fig. 185, and you will then have got over the entire difficulty. In the middle of the scale is one small hole. This hole is to come exactly over the mark

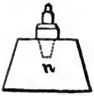

FIG. 183.

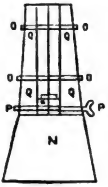

FIG. 184.

made with the bradawl at the balancing point, and if this be done all the rest must come right. Having thus marked the position of the holes, the next thing is to bore them. This is best effected by means of a bradawl driven by a mallet, the tourbillion during the operation being laid upon a small block of wood M, with a groove cut in it as *m*, Fig. 186 The holes should be as nearly as possible $\frac{3}{16}$ in. in size. It is easier to drive the bradawl with a mallet than to work it in with the hand. It must not be driven in farther than necessary, the object being merely to make a clear hole through. If a block is 2 in. square, or rather more, it will be quite large enough. The block will be found very useful afterwards. The two extreme holes, which are on opposite sides of the case, are made at the ends of the composition; the fire issuing from these gives the tourbillion a horizontal revolution round its centre of balance. The two inner holes, which are on the under side of the case, should be the same distance from one another that they are from the extreme holes; the fire issuing from these gives the tourbillion its ascending power. We have now to connect all these holes with quick-match, in order that the composition may take fire at all the four points simultaneously; and unless this is attended to with care, it will not only cause the tourbillion to fire irregularly, but entirely destroy its effect. Begin at one of the under holes, those marked F in Fig. 185, and press into it the end of a piece of uncased quick-match, taking care that the match reaches the composition. Then carry the match on to the nearest side hole, and press it into it. Carry on the quick-match over the under side of the tourbillion to the side hole at the other end of the case, and press it in there; and, lastly, carry it on to the remaining under-hole, and press it into it. Having completed this operation, cut some strips of thin paper, about 1 in. wide, paste them well over, and cover the quick-match with them, holes and all. A very little practice will enable one to adapt this pasted paper very neatly. The tourbillion, if now ignited, will be sure to go somewhere, but in order to regulate its flight we must adjust a stick to it, which shall have the effect of keeping its under side downwards, and so of compelling it to move upwards perpendicularly. This stick is usually made of beech, 8 in. long, about $\frac{1}{8}$ in. thick, and of a curved shape, in the manner represented at I in Fig. 185. There is a small hole in the centre through which a flat-headed nail is driven into the tourbillion at its balance point. The stick must, of course, lie at right angles with the case in the manner represented at R, Fig. 187. It is a very good plan to put a drop or two of glue at the point where the stick touches the case, as it

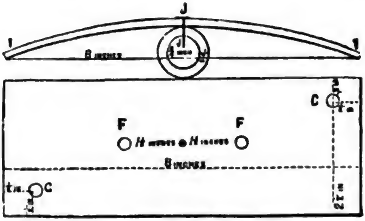

Fig 185.

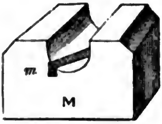

Fig. 186.

will then be prevented from shifting its position. In driving the nail through the stick into the tourbillion, make use of the block represented at M, having previously cut at the bottom of its rounded groove another small groove diagonally, so that when the tourbillion is lying upside down in the large groove, for the purpose of having the nail driven into it, the quick-match that extends across it may lie in the smaller groove, and may not be injured by being crushed, as would otherwise be the case. The nails used should be about ¾ in. long, and should have a smooth, flat head. To fire the tourbillion, place it stick downwards on a level board, and see that it spins easily and freely on the head of the nail. Then with a portfire burn through the quick-match in the middle on the upper side. The tourbillion will make a few revolutions on the board before it begins to rise.

Reference to Figs. 184 *to* 188.—M, block to receive the tourbillion while it is being bored. *m*, groove in it to receive the quick-match. N, block, with settle (*n*) over which tourbillions are rammed. Q, wooden cylinder to enclose tourbillion case. O, iron rings to tighten cylinder. P, pin to pass through cylinder and settle to connect them. R, tourbillion complete, with stick attached. S (Fig. 188), revolving cradle from which tourbillions are fired; and iron spike, with tubular top, in which the cradle revolves.

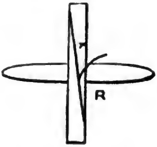

FIG. 187.

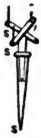

FIG. 188.

Pin, or Catherine Wheels.—Meal-powder, 8 oz. ; saltpetre, 4 oz.: sulphur, 3 oz. The pipe or case is made on a long wire former, about 3/16 in. in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about 1 in. in diameter, and not more than ½ in. thick, with a hole through the centre of it for a nail or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing wax, or a strip of paper pasted across the wheel. The end is then primed.

The wheels are spoken of as one-pipe, two-pipe, and so on ; which latter, however, does not mean that two pipes are wound round, or two are burning at once. It means that the tube of composition which is ordinarily 20 in. long, will, in the case of a two-pipe wheel, have another joined to it, and so be 40 in. long. For amateur purposes one pipe is long enough, and although it may be made a little thicker than usual, if desired, this is not particularly recommended. The former, or roller, is of brass wire, about 3/16 in. as stated, or say No. 7 gauge, and 25 in. long ; and for amateur work it is a great help if this can be made slightly taper, to facilitate the filling of the tube made on it. To do this it can be thickly soldered for a little more than half its length, and then filed true ; or some thin tape could be wound on it, this being painted over with a solution of shellac or sealing wax in spirits of wine, and then lightly rubbed down with glasspaper.

The rolling of the pipes requires practice. It is best done on several layers of paper and not direct on the bench slab, and although it may not be easy at first it becomes so after several trials. Some paper must be wasted, as when a trial paper is creased or slightly torn it is useless. It is good practice for the tubes in which the quick-match comes on set-pieces (lance-work) to be made in this way. An advantage of the taper tube is that it can be joined by slipping a small end in a large end, the two just fitting. The taper should be such that the large end of the former (roller) is half as large again as the small end.

The filling of wheel tubes is done by a funnel and rammer. The funnel is made very taper, its small end going into the large end of the tube about half an inch. The rammer is a piece of brass wire, one less gauge or thickness than the former, or say No. 8. This wire has any kind of knob on it to form a handle, and it is essential that it be kept smooth and straight.

When about to coil the filled tube around its wooden disc centre, it is necessary to damp the case a little to allow of its bending. This can be done by making a piece of cotton material wet, then wringing it out well and laying it on a board. Lay the tubes on this, then lay another similar piece of damp material over them and leave for an hour. Or the tubes may be rolled up in the material, not in a bundle, but covering each tube separately. The coiling is best done on a smooth level board or on a glazed tile, and is commenced by pinching the small end of the tube nearly flat for ½ in. of its length, then securing this end to the wooden centre by a touch of sealing wax. The coiling is then proceeded with, slowly and carefully, sealing-wax being used here and there if thought necessary, though an experienced hand only uses this a second time when the large end of the tube requires fastening. The cross-bands of paper on the sides of the wheel complete it. For those who wish to facilitate the winding of the tube on the centre, there is a small roller made which has flutes across it, so that by gently rolling this along the tube it slightly crimps it and makes the bending or winding easier. It may be added that the centres may be of thick cardboard if there is difficulty in getting wooden ones made.

Crackers.—The case is made of cartridge paper, a cheap quality is best, the dimensions required being 15 in. by 3½ in. First fold down one edge, about ¾ in. broad, then turn down the double edge about ¼ in., and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with powder, not ground very fine; the powder is then covered by the folds on each side, and the whole is pressed by a flat ruler. The part containing the powder is folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards and forwards in folds about 2¼ in., which are pressed quite close. A piece of twine is passed twice round the middle across the folds, and the joinings are secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed. As stated the powder should not be too fine, the FFF gunpowder being as good as any, and the tube when filled with powder and fastened up should be firmly rolled to make the powder cake a little. In doubling the tube to and fro to make it into cracker form, it may be found necessary to slightly damp it as described with catherine wheels.

Serpents, or Squibs.—(*a*) Meal-powder, 1½ lb.; charcoal, 4 oz.; sulphur, 1 oz. ; saltpetre, 3 oz.

(*b*) Meal-powder, 1¼ lb.; charcoal, 4 oz.; saltpetre, 6 oz.; sulphur, 4 oz.

The case is made by rolling cartridge paper in slips of 6 or 8 inches in breadth round a former, and pasting down the last fold, for serpents. The case, having been choked at one end, is filled by inserting a funnel into the case, filling the funnel with composition, and gently moving a rammer up and down the funnel-pipe, the rammer being introduced before the composition. The rammer has one or two grooves filed up the sides, to admit of the composition coming down while it is in the case. A piece of touchpaper is fastened to the end. For squibs, before filling the case, ram in hard a thimbleful of coarse gunpowder.

Squibs of good size are slightly choked (just squeezed in) at their mouths, and they are primed before the touchpaper is put on with a mixture of meal-powder 12 parts, saltpetre 6 parts, and sulphur 2 parts, slightly damped, and a small portion pressed into the choke before the touchpaper is put on. The opposite end of the squib is closed by pressing and then dipping in a mixture of hot glue and red-lead.

Showers of Fire.—*Chinese Fire.* Meal-powder, 1 lb.; sulphur, 2 oz.; iron filings, 5 oz.

Ancient Fire.—Meal-powder, 1 lb.; charcoal, 2 oz. To form a shower of fire, mould small paper cases on a rod, 3/16 in. in diameter, and 2½ in. in length. They must not be choked, as it will be sufficient to twist the end of the case, and having put the rod into it, beat it to make it assume its form. When the cases are filled, which is done by immersing them in the composition, fold down the other end, and then apply a match. They must be fixed on a frame with leaders, to be fired simultaneously.

Fire-Balloons.—The material for making a small balloon should be a fine thin, close-textured tissue paper. Having determined that the balloon shall consist of a specific number of gores or sections, say 8 or 16, a pattern for cutting them by should be made of pasteboard, or some tolerably hard substance. Suppose the entire height of the balloon, without its appendages, is to be 3 ft., and the number of gores 32, an elegant shape will be got by making the pattern 1 in. wide at one end, 3 in. at the other, and 8 in. at its broadest part, which should be at one-third of its length if the balloon is intended to have a pear-like figure. Varnish the gores with ordinary boiled oil, and hang them up singly on lines till perfectly dry. They are next to be put together, which may be done with gum water or clean thin paste. After pasting or gumming about ½ in. of one of the gores, lay the edge of another about midway across the part pasted, and then double over about ¼ in. of it, dabbing it lightly from end to end with a clean cloth, to ensure its holding securely. Two of the gores being thus united, unite two others in like manner, and so on, until, if there were 16 gores in all, the number is reduced to 8. In like manner proceed till the number is 4, and then 2; hanging the sections up at every pasting, so that they may get thoroughly dry whilst proceeding. The two halves are last of all to be connected in the same way; and this part of the undertaking is then completed. A circle of wire, about 6 in. in diameter, should be worked into the bottom of it, to keep the fabric of the balloon at a sufficient distance from the flame of the spirit. Another wire may be fixed across this circle to hold a piece of sponge, which should be immersed in spirits of wine. A smouldering piece of brown paper held underneath the aperture will in a few minutes put the balloon in an ascending condition. Having thus inflated the balloon, ignite the piece of sponge, and let it rise. When it is intended to inflate the balloon with hydrogen or coal gas, the latter apparatus is not needed; but a light car, or any other ornament proportioned to the ascending power of the balloon, may be appended to it, which will have the effect of maintaining it in the right position, and also of keeping it longer in sight than would otherwise be the case.

Drawing-room Fireworks.—*Lightning Paper.* Dry 1000 gr. pure nitre at a moderate heat, place it in a dry retort, pour on it 10 dr. by measure of strong sulphuric acid, and distil until 6 dr. nitric acid have passed over into the receiver. Dry some thin unsized paper, such as filter paper, and weigh out 60 gr. of it. Mix 5 measured drachms of the nitric acid with an equal volume of strong sulphuric acid in a small glass vessel; allow the mixture to cool; immerse the paper, pressing it down with a glass rod, cover the vessel with a glass plate, and set it aside for 15 or 20 minutes. Lift the paper out with a glass rod, throw it into a bucket of water, and wash it thoroughly in a stream of water till it no longer tastes acid or reddens blue litmus paper. Dry it by exposure to the air, or at a very gentle heat.

Japanese Matches.—Lampblack, 5; sulphur, 11; gunpowder from 26 to 30 parts, this last proportion varying with the quality of the powder. Grind very fine, and make the material into a paste with alcohol; form it into dice about ¼ in. square, with a knife or spatula; let them dry rather gradually on a warm mantelpiece, not too near a fire. When dry, fix one of the little squares into a small cleft made at the end of a lavender stalk, or, what is better, the solid straw-like material of which housemaids' carpet-brooms are made. Light the material at a candle, hold the stem downward. After the first blazing off, a ball of molten lava will form, from which the curious coruscations will soon appear.

Pharaoh's Serpents.—Fuse in a crucible equal parts by weight of yellow prussiate of potash and flowers of sulphur; it is frequently advisable, if the heat cannot be well regulated, to include a little carbonate of potash. Lixiviate the mass with water, and filter; the filtrate will be sulphocyanide of potassium, which, upon being added to a solution of mercury, dissolved in nitric acid, gives a copious precipitate of sulphocyanide of mercury. Collect this; wash well with water, and dry; roll into a small pyramid, cover with tin foil, and when dry it is ready to be lit.

Maroons.—These are miniature shells (with string instead of millboard casing), and need to be carefully made so as, firstly, to have no weak places that will spoil the report.and, secondly, not to missfire. Care should be observed in approaching or handling a maroon that has missfired.

Have a brass or wooden former that will make a tube 1¼ in. to 1½ in. diameter, and make a tube of any desired length on this, using stiff brown paper, previously soaking this well with paste so that it will set hard as wood. When the tube is dry, cut it into 1⅛ in. or 1⅜ in. lengths with a fine saw or on a lathe; each length will make a maroon. Procure discs of wood 3/16 in. thick, to fit the tube exactly, put a disc in one end and glue it in. Fill the tube with strong gunpowder, and then glue a wooden disc in the open end. Thus you have a thick and stiff drum of brown paper with wooden ends and filled full of powder. The next process is that of binding with string, and this is where care must be used to obtain good results. Careless binding means weak places, that will burst with comparatively small pressure and so make the explosion quite a weak one. The best plan is to mark out each end of the drum into six divisions and wind each separately as Fig. 189, this systematic plan ensuring a complete covering. The string should be of a strong well-twisted kind, 1/32 in. to ⅛ in. thick, one end tied to a staple in the wall, while the ball of string lies loosely on the ground. By this plan, and giving the string a twist round the right hand, a good tight binding can be effected after a little practice. The binding must be kept taut all the time, or, should it loosen, part will slip off. To assist in the binding, the edges of the drum may be notched.

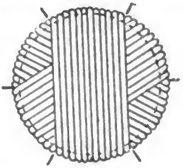

FIG. 189.

When the binding is effected as Fig. 189, it may be assumed that the whole of the drum is covered; and what remains to be done is to give about twelve turns around the circumference of the drum, and finish off with a loop to hang the maroon by after the next process.

Having completed the cording, make a mixture of hot glue and red-lead, rather thin, and while hot paint the maroon with it, using a stiff brush and every effort to work the glue between the strings, to solidify the whole. Hang it up by the loop to dry, and, later on, give it a second coat. When this is dry, the loop can be cut off.

The final thing to be done is to provide a means of firing it. Touch-paper alone is sometimes used, but it is very uncertain. The better plan is to make a small squib or serpent and insert this. Bore a hole in the maroon with a copper tool right through to the powder. Let the squib have its lower end open and then insert it, making quite sure that the composition of the squib and the powder of the maroon are together, then glue the squib in. The squib would be fired by a piece of touch-paper as usual.

Shells. — These are used exclusively for exhibition work and serve excellently for this purpose. They are fired from mortars (short cannon), and the size of the bore of the mortar gives the size to the shell; thus a 6 in. shell would have an external diameter fully ⅛ in. less.

The shells are spherical, and the cases that have to be made are half or hemispheres, these being made of brown paper (about 70 lb.) of fairly common quality, not too tough, and a thinner paper such as newspaper. Probably the easiest plan for the amateur to adopt—as not requiring metal moulds—is that of pasting the paper over a ball as follows : First take some strips of brown paper, about 12 in. by 5 in., torn, not cut, and soak these in boiling water one or two at a time. As soaked, pile them in a little heap to drain. Now take them one by one and paste them on both sides, and make another heap of pasted papers. Treat the newspaper much the same, except that the first soaking must not be too great for such light stuff. Having prepared the paper, take a wooden ball—a croquet ball if of the right size—and first put a piece of dry newspaper on this, pasting the edges where they meet but not pasting it on to the ball ; press it round all ways with the hands until it covers the ball as smoothly as its creases will allow. Now take some of the narrowest strips of pasted brown paper, and put them on all ways until the newspaper is covered. Now give a coat of pasted newspaper, following with brown until there are three coats of each, six in all. Now put the ball to dry in a warm oven and when dry make a mark round its centre, and then, with a pointed knife, carefully cut through to the ball. About half an inch of the circumference can be left uncut to form a hinge, if desired. When the ball is removed, bring the edges together again and paste a strip of newspaper round them. The case now has six more coats of pasted paper, three of brown and three of newspaper, pasted all ways so as to secure the joint ; but, before giving these coats, it is well to stick a tack or pin in the centre of one of the half shells (thus, if we call the cut the equator, the pin can be put at the north-pole), so that when the pasting is finally done the pin will show where the joint does not come. The reason for this is that a hole has lastly to be made to take the time fuse, and this should not be at the joint or too near to it ; therefore, by making the hole where the pin is, there is no risk of this. Before making the hole, however, the case must be finally dried. When the case is dry, the hole for filling and for the fuse is made. This can be cut, stamped or burned in, according to how the case is made. For that just described a small poker, made nearly red hot, does as well as anything.

Perhaps the next thing to describe is the making of the time-fuses. A composition of meal-powder 5 oz., saltpetre 5 oz., and sulphur 2 oz., is used for these, this being rammed hard into a ½-in. strong squib-case. The case is then cut into ¾ in. lengths by a fine saw, each length being a fuse suited for shells up to 5 in. Each fuse is primed at one end with meal-powder made into a paste, into which is inserted a little piece of quick-match, frayed at the exposed end, as Fig. 190.

The shell is filled quite full with stars, a 3-in. shell taking about 5 oz., while a 4½-in. takes a pound, and so on. On to the stars pour about half an ounce of fine meal-powder and shake it in. Now put a piece of linen material around the fuse, standing up about an inch above it, as shown by dotted line in Fig. 190, and then glue it into the shell, letting it project about ¼ in. When the fuse has set hard in its hole, the match for the firing or blowing charge may be adjusted. Have a piece of quick-match about a foot long, according to the size of the shell, and cover this with its usual paper casing or pipe. At its centre leave about ½ in. uncovered, also about 1 in. at each end. Now make two holes in the linen sleeve one each side just level with the top of the fuse, and through these put the length of quick-match so that its uncovered part in the centre rests on the fuse as Fig. 190. When in position put a little meal-powder paste to secure the match to the top of the fuse, inside the linen sleeve.

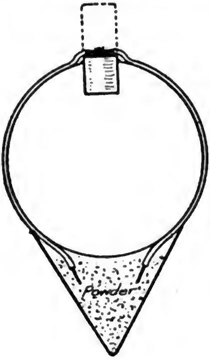

FIG. 190.

Having proceeded so far, have a stiff cone prepared (made on a tool much like that used for rockets, Fig. 191), to attach to the bottom of the shell. To do this a square block stand is required, this having a conical hole sunk in it and into which the cone is put. The hole is not deep enough to take the whole of the paper cone, but leaves about 1 in. of its top edge standing out. Put (for a 3½-in. shell) 2 oz. of F.F.F. gunpowder into the cone; then place the shell on top, arranging that the two free ends of the quick-match come down and be imbedded in the powder as shown. When this is done cover the joint between the shell and the cone with thin paper pasted on, and stand the whole aside to dry. To complete the shell, first paste a thickness or two of paper over the quick-match where it passes down each side of the shell, thus securing the match to the shell, and see that there are no open joints where the match enters the cone. The next thing to do is to connect the "leader." This is a length of cased quick-match, one end of which comes tight on to the priming over the fuse. When in this position the linen sleeve is tied securely round it. The leader, which is long enough to project over the edge of the mortar (from which the shell is fired), has its other end bare of casing for an inch, this inch being covered with touch-paper for firing.

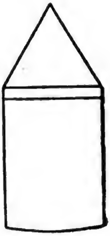

FIG. 191.

The mortars for moderate sized shells are upright cylinders of stout sheet-iron plate about (16 gauge) standing 18 in. to 24 in. high. The top edge or breech is strengthened with a heavy bead or band, while the lower edge is turned out and screwed down to the stand or base. This base has a conical depression inside the mortar, to take the cone of the shell when it is put in. To strengthen the mortar, it is sometimes bound with cord, then painted.

* * *

FLOORCLOTH AND OILCLOTH.

(*a*) IN America the manufacture of oilcloth is an industry which is carried on with the aid of very simple machinery—machinery so simple, in fact, that it is seldom out of order, and the costs of repairs are trifling. The buildings in which the operations are carried out are constructed on an entirely different plan from large machine-shops, the tendency being to minimise the ever-present danger of fire by locating the different steps of the industry in as many buildings as possible and isolating them. The plant which we describe is one situated on the crest of a hill in a suburb of the old city of Brooklyn, known as Fresh Pond. The buildings and grounds are 26 acres in extent. The various drying-houses are separated by a series of great buttressed firewalls, which sometimes form the end of one of the buildings but are generally separated from each building. These walls are perforated by fireproof doors, which permit of rolls of oilcloth passing through them on the elevated platforms called "railways." Should a conflagration occur in a building, sprinklers and fire-pumps are automatically operated to extinguish the flames.

Oilcloth consists of burlap canvas, which is painted repeatedly with a body colour and then printed with a pattern consisting of 2 to 10 colours. The burlap, which comes from Scotland, is brought to the factory in bales containing 12 to 15 bolts of 152 yd. each. Burlap used is made in six widths, 38, 47, 56, 74, 75, and 93 in. wide, though for special use it is made narrower, as for stair oilcloth. The bolts of burlap are sewed together by women in the basement of one of the buildings, in order that a large roll may be obtained to be sized and dried. The object of the sizing is to stiffen and give a surface which will take the paint, and in the cheaper and lighter varieties of oilcloth the back is not painted, therefore in this case the size is dyed. The size is made on the floor above, and is allowed to flow while hot into the vat. The burlap passes under a roll in the bottom of the vat, then up under a bar known as a "knife," around the pair of rollers, and is finally wound on a great bobbin. Five of the bolts of cloths form a single roll. Beyond the sizing machine is a blower and air heater, which furnishes an enormous volume of hot air to be used in drying the sized burlap. The wet rolls are taken to a room on the floor above, which immediately adjoins the drying-room. Here they are pulled forward by pins which are attached to endless chains, and pass underneath a sash of a window and out on an iron framework, which is boxed in, and which receives the heated air from below. The burlap makes three turns of this drying arrangement, which is 60 ft. long. As the temperature in the room is 220° F., no men work in it; but the course of the cloth may be watched through windows at either end. The calendering rolls and the endless chains are operated by a two-cylinder engine. As the burlap emerges from under the window-sash it is automatically marked into lengths, and then passes over three calender rolls, which are heated by steam, which press and iron it. The burlap is then drawn from the calenders by tension rollers, and is cut off into lengths and rolled up.

These pieces of cloth are then taken to the buildings where the body colour is put on. There are three of these buildings, each very large, being usually five stories in height, and wide enough to permit of a considerable number of racks on each floor. All the paint used is ground and prepared on the premises, the linseed-oil being kept in two large iron tanks in the yard, holding 250,000 gal. The paint is brought to each floor in tubs, which are wheeled to the painting machines. These machines are of the utmost simplicity, and are very effective. They move across the width of the building on a track, in order that they may be brought in front of each row of racks; for after the burlap is painted, it must be allowed to dry in a rack by itself, out of contact with other pieces. The racks are built of yellow pine, and a considerable portion of the floors of the buildings are likewise slatted to allow of free circulation of air. At night, steam is turned on to assist the drying, and sometimes in cold weather steam is used in daytime. The roll of sized and dry burlap is put on a reel, and it then passes over two pads and under two knives. The paint is thrown on to the burlap by dipperfuls, the knife distributing it evenly. The piece of cloth, after being painted, is pulled on to one of the racks, which are 76 ft. long, and there are 24 tiers of them on each floor, and the buildings have generally 7 ranges. In all, there are 5533 drying frames, aggregating 276,000 sq. yd. of space. The end of the oilcloth is secured by a clamp. A rope is attached to this, and threaded through the proper slats in the drying-frame by a workman, who walks through a narrow hallway between each pair of racks. The end of the rope is brought out, and 3 or 4 turns taken around the winch-head. The speed is adjusted by friction, so that the cloth is pulled steadily through the painting machine at the proper speed. When the entire 24 pieces of cloth have been painted, the machine is moved sideways until the next rack is reached. Considerable frictional electricity is generated at the painting machine, and a wire at the top conducts it to the ground. The paint on the cloth dries in the space of a day or so, and the cloth is then rolled up and taken to a rubbing machine. It consists of a pair of parallel bars, which are actuated in opposite directions with the aid of gears and cranks. Each bar carries a number of pumice-stone blocks, which serve to smooth the surface as the painted burlap is drawn through it.

Sand is also thrown upon the cloth, to assist the action of the rubbing blocks. The painted burlap is rubbed after each coat, and the number of coats depends upon the grade. In the most expensive oilcloth four coats are given on the face and two on the back, and, as it requires a day or so between each step, it will be seen that a considerable period must elapse before the oilcloth is ready for printing. In the cheapest oilcloth one coat is given to the face and none to the back. The edges are trimmed before printing.

Oilcloth may be printed both by hand and machine, hand work being used for the heaviest and best grades and for samples; but the machine work is faultless. The printing blocks are of three varieties, pin or line blocks, depending on whether the pattern is produced by incised lines or by separate wooden pins, and metal blocks. Pin blocks are made by taking a piece of maple and sawing it both longitudinally and transversely with a series of fine saw-cuts which form small square pins; the ones not needed in the pattern are chipped out. In the line blocks, parts of the continuous lines not needed are cut away. Blocks are required for each colour, and some patterns require as many as six or ten colours. The machines are over 50 ft. long, and the oilcloth is fed in at the rear and is pulled forward 18 in. each time the blocks descend. As was the case with the painting machine, this entire printing machine moves up and down the room, in order that the printed pieces of cloth may be delivered to the different sets of drying-racks. The printing blocks are secured to cross-pieces of frames, which move vertically with the aid of cams. The blocks are inked by rollers which run in boxes, the boxes being filled with paint. Each roller inks one block, which prints one colour. In operation, with the aid of a so-called crooked wheel, the painted burlap is moved forward, and at the same time all of the printed blocks descend, each printing its own colour. Thus at the first block only one part of the pattern in one colour will be printed, while at the last block the entire pattern of oilcloth is completed. As the blocks rise, the ink roller runs under the blocks and inks them, rolls back from underneath, and the block descends again. On each pattern is a block called a masher, which is simply an uncut block with all pegs or lines left in place. This spreads and smooths the paint in descending.

As the printing progresses, the piece is drawn into the drying-room. Owing to the fire underwriters' ruling, the buildings are kept isolated, so that in this case there is no direct communication between the printing-room and the drying-house. This difficulty is got over by a series of iron doors, which permit of the piece of oilcloth being drawn through them. Each time the machine is moved it is drawn in front of one of these doors. A movable shed, one story in height, passes up and down outside the building, and the oilcloth is drawn through this movable shed into the drying-house. Once in the latter the oilcloth can be raised to any floor through traps, and is drawn through the racks as before. It requires from three to twenty days for the printed oilcloth to dry. The oilcloth is then rolled and dried again for a month or so.

Hand-printing is used exclusively for samples, and very largely for the heaviest oilcloth. The principles involved do not differ from those in which the machine is used. The block, which is 18 in. square, has a handle, and is linked upon a pad, the paint being supplied and spread with the aid of a bristle-brush. After all of the colours have been applied, and a masher used to spread the colours, the oilcloth is pulled forward 18 in. by a rope, and the next section is printed. The oilcloth is pulled into the drying frames as before.

After the finished product has become perfectly dry and hard, it is taken to a varnishing-room. The varnishing machine consists of a metal trough which holds the varnish. When it is turned down the varnish runs out of twenty spouts, distributing it evenly over the oilcloth, which is rapidly drawn between a metal and a printer's roller, the latter spreading the varnish. Workmen, with the aid of brushes, serve to distribute the varnish. The oilcloth is hauled into the drying-racks as before. After it is entirely dry, it is rolled up and stored with other rolls of its pattern in a warehouse. An open crate or shook is used in packing the oilcloth for shipment. ('Scientific American.')

(*b*) The main part of the manipulation of oilcloth is similar to calico-printing, the figures upon the blocks being upon a much larger scale, and the cloths which are printed being of much greater size. The common dimensions of a floorcloth are 210 or 220 sq. yd. A stout canvas is chosen in the first instance. This is nailed to one extremity of a wooden frame, and stretched by means of hooks which are attached to the other side. It is then washed with a weak size, and rubbed over with pumice. No other substance has yet been found which answers the purpose so well as this mineral. The next step is laying on the colour, which is performed by placing dabs of paint over the canvas with a brush, and then rubbing or polishing it with a long peculiar-shaped trowel. Four coats of paint are thus applied in front, and three on the back of the cloth. To remove it from the frame when these processes are finished, a roller on the carriage is employed, upon which it is rolled, and conveyed to the extremity of the manufactory for the purpose of being printed. It is then gradually transferred from the roller and passed over a table which is 30 ft. long and 4 ft. wide, and as it proceeds over the table, the blocks, dipped in the appropriate colours, are applied. The colours used are ochre, umber, vermilion, and different kinds of chrome, mixed up with a little linseed-oil and a little turpentine. The number of blocks applied to one pattern depends upon the number of colours. The first mode of applying the patterns was by stencil plates. Then a combination of stencilling and hand-printing was used, the former process being first made use of; afterwards a block was applied, the stencilling forming the groundwork. Stencilling is now abandoned. In printing, it is necessary that the cloth should first be rubbed over with a brush, or else the colours will not adhere. Every square yard of good oilcloth weighs 3½ lb. to 4½ lb., each gaining by the application of the paint 3 lb. or 4 lb. weight, and hence the quality of this manufacture is judged of by the weight. Whiting mixed with oil is often used in spurious cloths. Cloth prepared in this way speedily cracks and becomes useless. Good cloth, with a very stout canvas, is used for covering verandahs, and will last nine or ten years, while common cloth will become useless in one year.

(*Note.*— Valuable information on this subject is given in 'Spons' Encyclopædia of the Industrial Arts,' to which the reader is referred for illustrations of the machinery employed.)

* * *

FOUNTAINS.

ILLUMINATED OR PRISMATIC.

THE popularity of these fountains was first gained by the exhibit that was made at the Health Exhibition, public attention being drawn to the novel and splendid effect produced by what appeared to be illuminated water. The exhibition was, of course, at night, and all the spectators saw, was columns and showers of what might be described as gorgeously brilliant gems. Nothing was visible to show how the water was given its luminosity, and the delicate colouring which was changed every few minutes was equally puzzling. The theory generally spread and accepted by the uninitiated public was that a discovery had been made that water would absorb and hold light for a short period, and that the fountains were displaying water possessing this quality. As a matter of fact the whole effect was due to beams of light suitably directed on the water, the source of light being hidden; and where the cleverness of the plan appeared was in finding that these beams, when caused to light up broken water, did not give any evidence of their existence except in the sparkling of the water. There was no clearly defined beam—no visible beam at all—only brilliantly glistening water particles. At the Exhibition named, the chief column of water was about 25 ft. high, and its highest particles were bright. Needless to say, the light at the base was a powerful one.

The example here given is the description of what more approaches a toy, but it will serve quite well to illustrate the principle. Fig. 192 shows the effect that may be aimed at, though in large undertakings, it is not necessary that any "stage" surroundings be provided. An open fountain can be utilised provided a chamber is made beneath it for the operator, the light, etc. For indoor use some scheme as Fig. 193 is desirable In this we

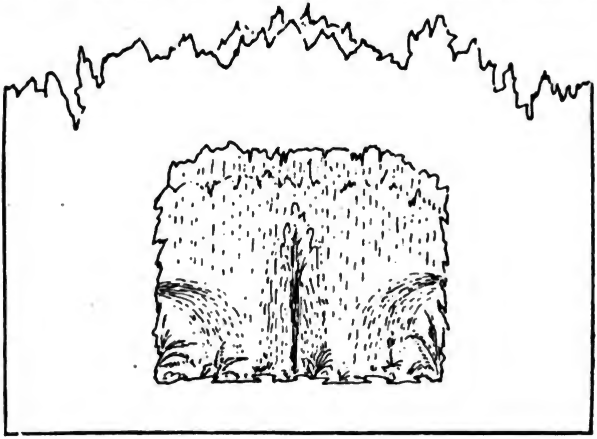

FIG. 192.

have three different "effects." Firstly there is the ascending column of water in the centre; secondly two side flows or pipe cataracts; thirdly, a rain shower. Any of these can be tinted by the use of coloured glasses between the light and the moving water, and any may be coloured independently, so that some very artistic colouring effects are possible. Virgin cork may be used for the front of Fig. 192, while accommodation may be made for the temporary insertion of small pots of ferns and the like.

Fig. 193 shows the necessary details stripped of the ornament. The upper tank, which supplies the side cataracts and the rain shower, should be large enough to keep the fall of water constant some time. If a regular supply of water can be brought to it, by a rubber-tube, from an adjacent tap, so much the better. The side cataracts could start by a single pipe from the upper tank, if desired, it being then possible to control both at once by a single stop tap; or they may be distinct, as shown, with a stop tap in each. The lower tank is merely to receive the falling water, and requires an overflow pipe. This pipe can run into a pan, which must be watched and emptied; or it may be possible to carry the overflow (by a rubber tube) to an adjacent gully.

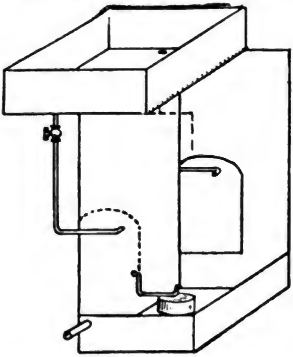
FIG. 193.

An important detail is the lighting of the upright column or jet. Fig. 194 gives the particulars of this. A circular lens is arranged to come at a suitable central point, the glass and its frame being water-tight. The glass is not specially ground, being only a piece of ordinary plain glass. Over the centre of this the jet is fixed as shown. Beneath this the source of light may be fixed, or a beam of light may be directed to it by a mirror placed at 45° as illustrated. It is desirable, in fact necessary, that the water supply to this jet come from a higher source than the tank that is just over it. If a house tap is available, a piece of rubber tube will bring the water from it with abundance of pressure; but, failing this, a separate tank must be provided.

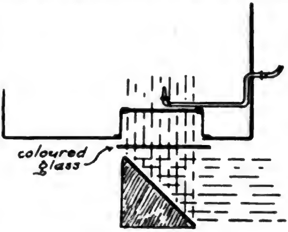

FIG. 194.

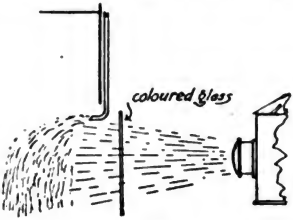

FIG. 195.

This could be a large oil-can, with nozzle and tap soldered in the bottom; this can being filled with water and hung up on the wall at a suitable height.

Fig. 195 shows the simple detail of illuminating the side cataracts. In this, as with Fig. 194, provision can be made for sliding in coloured glasses between the light and the water. These are shown in both illustrations.

* * *

FOUNTAINS, SELF-ACTING.

FIG. 196 is the form in which the parts of a self-acting fountain are usually arranged. To set this to work the cork marked "plug" is removed, and water poured into the container 2 until it is nearly up to the top of pipe 5. No water must go into chamber 3. When the chamber 2 is filled, put the plug back soundly and fill the open basin 1, but previously plugging the top of pipe 4 with a cork. When the basin 1 is full, remove the cork from the top of pipe 4 and let the water run down into chamber 3. This will cause a compression of air there, which, transmitted up the pipe 5 to chamber 2, will cause water to be elevated from the fountain jet. The fountain will be in operation until it has displaced the air from chamber 3.

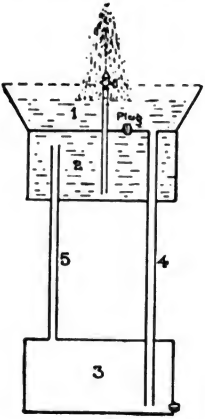

FIG. 196.

Fig. 197 may be said to resemble Fig. 196, but is ingeniously arranged to be reversible, so that when the fountain ceases to play it can be reversed and bring another into operation, and while the latter is playing the first one rights itself in readiness for duty again. To operate this, pour water into the top open basin or pan and it will pass down pipe 1 to fill chamber 2, the air from this cistern passing out up pipe 3 into the upper chamber. From here, the jet being open, the air escapes to the atmosphere. When the lower chamber 2 is full, open tap 4 and let a little water rise into the upper chamber, after which close the jet cock and *then reverse the fountain*. The fountain turns on the arms 5 5. What was the top fountain is now the bottom one, and a glance at the illustration will show that the water then reverses itself in the chambers provided the cock 4 is open to let the air ascend into what was the bottom chamber. Now repeat the filling with the new upper (and empty) fountain in just the same way. Having done this, it is only necessary to reverse the fountains again, bringing the original top one to the top once more, and this will at once commence to play if the jet cock is open. The lower one will also be preparing itself to play when its turn comes. The tap 4 must be closed each time the fountain is brought up to play, and opened each time the fountain is turned downwards to recover itself. The corks 6 6 are for emptying when required. The cone and collar rings in each basin (around the jet) are to receive water, and hold it when each fountain is reversed and upside down.

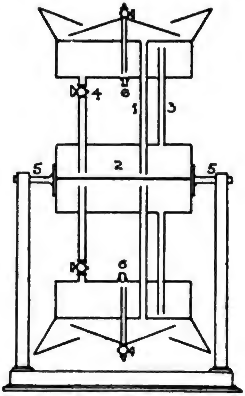

FIG. 197.

Fig. 198 is a simple fountain operated by compressed air. The body is filled about one-third with water, leaving a good air-space above, into which air is compressed, through the cock shown, by a strong bicycle pump. If the jet is a fine one the fountain will operate about one hour, and is therefore suited for the dinner table if surrounded by ferns or is arranged to take flowers round it. It must be fairly strong to withstand the pressure of the compressed air, and the open pan at top must be large enough to take all the water. A screw-plug at the bottom of the pan will allow of the water running back into the chamber when refilling or filling is done, the plug being replaced before pumping air in.

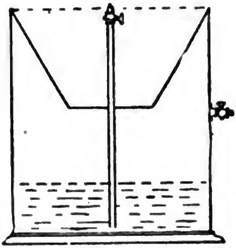

FIG. 198.

* * *

FREEZING-MIXTURE.

HEAT is absorbed in bringing solids to the liquid condition, and the cold thus produced may prove sufficient to convert water into ice. The salts commonly employed for this purpose are termed "freezing-mixtures." They are chiefly as given in following table. The best known of the numerous freezing-mixtures that have been hitherto described consists of 3 parts ice, and 1 of ordinary salt. Dissolving concurrently these two substances give a temperature of—5·4° F. (21° C.), the freezing-point of the solution. The melting of only a part of the mixture is sufficient to produce this temperature throughout the mass; and

Mixtures.	Thermometer sinks: °F.		Actual Reduction of Temperature. °F.
	°	°	°
(1) 2 parts snow or pounded ice, 1 sodium chloride	from any temperature	to -5	..
(2) 5 parts snow or pounded ice, 2 sodium chloride, 1 ammonium chloride	..	to -12	..
(3) 24 parts snow or pounded ice, 10 sodium chloride, 5 ammonium chloride, 5 potassium nitrate	..	to -18	..
(4) 12 parts snow or pounded ice, 5 sodium chloride, 5 ammonium nitrate	..	to -25	..
(5) 3 parts sodium phosphate, 2 ammonium nitrate, 4 diluted mixed acids	from -34	to -50	16
(6) 8 parts snow, 10 dilute sulphuric acid	,, -68	to -91	23
(7) 1 part snow, 3 crystallised calcium chloride	,, -40	to -73	33
(8) 5 parts sodium phosphate, 3 ammonium nitrate, 4 dilute nitric acid	,, 0	to -34	34
(9) 1 part ammonium nitrate, 1 water	,, 40	to 4	36
(10) 5 parts ammonium chloride, 5 potassium nitrate, 16 water	,, 50	to 10	40
(11) 1 part snow, 1 dilute sulphuric acid	,, -20	to -60	40
(12) 3 parts snow, 2 dilute nitric acid	,, 0	to -46	46
(13) 8 parts snow, 3 dilute sulphuric acid, 3 dilute nitric acid	,, -10	to -56	46
(14) 5 parts ammonium chloride, 5 potassium nitrate, 8 sodium sulphate, 16 water	,, 50	to 4	46
(15) 5 parts sodium sulphate, 4 dilute sulphuric acid	,, 50	to 3	47
(16) 3 parts sodium nitrate, 2 dilute nitric acid	,, 50	to -3	53
(17) 2 parts snow, 3 calcium chloride	,, -15	to -68	53
(18) 3 parts snow, 2 dilute sulphuric acid	,, 32	to -23	55
(19) 1 part ammonium nitrate, 1 sodium carbonate, 1 water	,, 50	to -7	57
(20) 8 parts snow, 5 hydrochloric acid	,, 32	to -27	59
(21) 6 parts sodium sulphate, 4 ammonium chloride, 2 potassium nitrate, 4 dilute nitric acid	,, 50	to -10	60

Mixtures.	Thermometer sinks °F.	Actual Reduction of Temperature. °F.
	° °	°
(22) 9 parts sodium phosphate, 4 dilute nitric acid	from 50 to –12	62
(23) 7 parts snow, 4 dilute nitric acid	,, 32 to –30	62
(24) 1 part snow, 2 crystallised calcium chloride	,, 0 to –66	66
(25) 3 parts snow, 4 calcium chloride	,, 20 to –48	68
(26) 4 parts snow, 5 calcium chloride	,, 32 to –40	72
(27) 2 parts snow, 3 crystallised calcium chloride	,, 32 to –50	82
(28) 3 parts snow, 4 potash	,, 32 to –51	83
(29) 6 parts sodium sulphate, 5 ammonium nitrate, 4 dilute nitric acid	,, 50 to –40	90

with constant admission of heat, and stirring, the low temperature is maintained till the whole is dissolved. The freezing apparatus of confectioners is well known: a tin pot containing cream, a wooden or metallic vessel enclosing the pot, and the interval filled with ice and salt, which is frequently stirred, that the ice may not sink to the bottom. In a Paris machine, for home use, the agitation of the freezing-mixture is maintained by rotation of the double cylinder containing it and the cream vessel round an axis at right angles to the cylinder's length. Meidinger has constructed a machine based on the observation that a solution of ordinary salt under 32° F. (0° C.) also fuses ice, and, so long as its concentration is maintained, produces the same low temperature as the mixture of salt and ice. He provides a sieve-like vessel, containing salt, to maintain the concentration as the ice melts. The lowering of temperature is uniform throughout the vessel, and no stirring is required. The machine has come largely into use in perfumery.

(*c*) On the basis of his own experiments, Meidinger has formed a table showing the respective merits of various freezing-mixtures. The extract on page 327 contains the most serviceable.

Salt mixtures give much greater lowering of temperature than simple salts, as they dissolve in much less water. Thus, 1 part sal-ammoniac is dissolved in 3 parts water, and lowers the temperature about 19° C.; saltpetre dissolves in 6 parts water, and lowers the temperature about 11° C. (Compare the fourth and fifth on the list.) It will be seen that the salt-ice mixture proves considerably more energetic and cheaper than any of the others so far as use of the materials only once is concerned. The second mixture, too, cannot be restored; nor can the last, easily, on account of the crystallised Glauber salt. Both are comparatively cheap, however. The mixture, in which, by vaporisation of the solution, the salt is easily renewed in its original condition, ammonia nitrate and sal-ammoniac, is so costly at the first, that it would not do to use it only once. This was the mixture employed in an apparatus first exhibited by Charles at the Paris Exhibition in 1867. The tin vessel containing the substance to be frozen is enclosed in a large wooden vessel containing the freezing-mixture, and is furnished with screw wings, which stir the mixture as the vessel is rotated.

Mixture.	Decrease of Temperature. C.	Specific heat of the solution.	Volume weight of solution.	Loss of heat units		To use for 120 c.		
				1 kilo. Mixture.	1 litre Mixture.	Salt kilo.	Water kilo.	Cost s.
1 ordinary salt, 3 ice . . .	21°	0·83	1·18	125	100	0·5	1·5	0·34 to 0·12
3 cryst. Glauber salt, 2 concd. muriatic acid	37°	0·74	1·31	55	74	2·7	1·8	1·0 to 0·6
2 ammonia nitrate, 1 sal-ammoniac, 3 water . .	30°	0·70	1·20	42	51	3	3	7·6 to 6·8
3 sal-ammoniac, 2 saltpetre, 10 water . .	26°	0·76	1·15	40	46	3·1	4·2	2·6 to 2·2
3 sal-ammoniac, 2 saltpetre, 4 cryst. Glauber salt, 9 water . .	32°	0·72	1·22	50	61	2·5	2·5	1·8 to 1·6

* * *

FUEL ECONOMY.

UNDER the pressure of circumstances great attention has of late years been given to the study of close economy in all branches of manufacture, and particularly to the standing charges which form so large a proportion of the cost of a large works. The control of coal consumption is one question which merits the greatest attention, since a saving in coal alone will in many parts of the world in itself aid largely in increasing the profits of a concern. Great attention has been devoted to automatic stoking and smoke consumption appliances, but all these appliances must fail in their object unless some means is provided of automatically and continuously indicating to the attendant in charge of the boilers the exact state of furnaces under his care, while at the same time furnishing a continuous record accessible only to the manager whereby they can check the efficiency of the firing. Since the production of steam is effected by the combustion of fuel, there can be no better or more effective method than the rapid and continuous analysis of the product of combustion delivered to the chimney; for the condition of the gases in the place will at once show if the combustion of the fuel is complete, this being, in short, evidenced by the proportion of CO_2 contained in the flue gases. The fireman cannot be responsible for the type of boiler and furnace under his care, and is indeed never consulted in such matters, but he can, by studying the proportion of CO_2 in the flue gases, arrive at a very close approximation to the actual efficiency of his control of the firing. To achieve this rapidly, automatically and continuously, while at the same time presenting the results in a form understandable to any intelligent man, prevents many difficulties, but the apparatus invented by Simmance and Abady does do this with admirable simplicity. A diagram of the apparatus devised by them, and manufactured by Alexander Wright and Co., is shown in Fig. 199. The apparatus is placed in an accessible position in the boiler room, and a connection is made from it to the base of the flue.

There are three principal vessels or holders in this apparatus: the tank A, the extractor P, the analyser J.

A dribble of water is the motive power for effecting the whole of the operations described below:—

Water is allowed to drop into the tank A from a ball valve cistern. In the tank there is a float B, which is attached by means of a chain C to the bell D of the extractor, and this float rises and allows the bell D of the extractor to fall. Assuming that the bell D of the extractor is empty, then the float B in the tank A would be near the top, and as it gets near the top it engages with the drip valve E on the water service F, quickening the supply for a moment and starting an automatic syphon G. The drip valve is not a necessity, but is supplied where the water supply might be irregular and interfere with the regularity of the syphon. The syphon actuates the balance valve H which opens the way from the flue to the extractor, and vents the analyser J. Naturally, as the water syphons out of the tank A, the float B inside drops, and being heavily weighted, pulls up the bell D of the extractor, which is suspended in a vessel filled with oil, and thus collects a quantity of gas from the flue. Now as this bell D rises, the small tube K (which will be seen depending from the crown of it) is lifted out of the small vessel L which contains the oil, and as this bell D has been sucked up, as it were, a plug of this liquid is also sucked up into the small tube K, completely sealing it. Now what next happens is that, the syphoning being finished, the way from the flue is automatically shut off by the balance valve H. The water is now running into the tank A, lifting the float B, and allowing the extractor bell D to fall. As it does, so it will be seen that the contents of the bell D (which by the closing of the valve H are now uninfluenced by vacuum or conditions in the flue) are first reduced to atmospheric pressure, and then are actually under pressure, and part of the contents will therefore blow out through the little tube K which has first discharged its liquid plug. The bell D still falling, the little tube is then sealed by the liquid in the small vessel L, imprisoning a definite quantity of gas, and there arrives a point when the resistance offered by this sealing is greater than the weight of the analyser bell J, and the volume of gas is therefore transferred (by bubbling through the separate iron vessel M containing caustic potash solution) to the analyser J. The whole point is that by adjusting the height at which the little tube K seals itself in the liquid L we can lessen or increase the amount of gas sent forward into the analyser J (and we make this adjustment so that the volume from 0 to 100 on the engraved scale N is transferred when the apparatus is being set by air containing practically no CO_2). When the flue gas has been turned on to the apparatus and transferred from the extractor D into the analyser J, the CO_2 has been absorbed by caustic potash in the iron vessel M, and, owing to such absorption, the analyser bell J will not rise to its full height. We allow it to automatically rise as far as it will, carrying with it a pen which marks on the chart the final position of the analyser bell J. The percentage of CO_2 in the gas is thus automatically recorded. This bell J then vents, sending out the analysed gas by a separate channel and

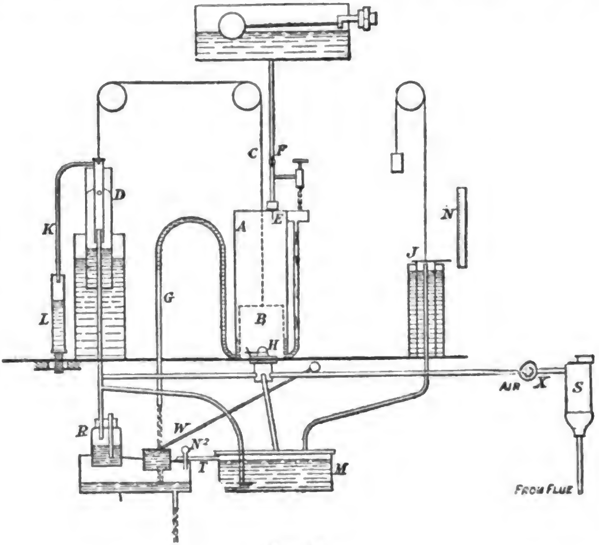

FIG. 199.

without mixing or coming in contact with the fresh charge of gas, and a new charge of gas is brought forward to be dealt with in exactly the same way, the whole of the operations taking place automatically by means of the dripping water.

Note. — It will be seen that the correctness of the record depends upon the maintenance of the level of liquid in the sealing vessel L, which level is kept practically constant.

R is a small seal bottle, and the glass open ended tube should enter the liquid (oil) about 1 in. to 1½ in., and is a safety device to guard against the liquid being slopped over, if either of the bells were carelessly pulled up by hand.

The proper understanding of the seal bottle is very important, not that it affects the correctness or capacity of the instrument, but because it indicates at once whether there is any stoppage in the pipes leading the gas to the CO_2 recorder, as is explained more fully in the instructions for fitting up.

In the diagram, the clock drum with chart is omitted for the sake of clearness. The potash is put in a separate vessel so that it only requires charging every six weeks or two months, which is a great advantage.

* * *

GALVANOMETER.

To every worker in physics or electricity a good and reliable galvanometer is a prime necessity; but the prices asked for such by instrument makers often constrain one to get along with some rude and imperfect makeshift. But at a merely trifling expense, an instrument may be made which shall be equal in performance to any that can be bought, and which requires but little mechanical skill on the part of the maker.

Procure 1 ft. of 3-in. brass tubing, 5 in. of 2½-in. tubing, 6 discs of brass plate 3 in. diameter, and a piece of hardwood plank, or, better, vulcanite, the latter to serve as a base to the finished instrument. From the 3-in. tube saw a piece 2¼ in. long and nicely square its ends. This is for the body or barrel of the galvanometer. Crosswise of this, and midway from either end, a slit 2 in. long and ⅛ in. wide is next to be made.

Now take the 2½-in. tube, and with a broad half-round file fit one end of it to the side of the barrel—a rather difficult feat for a novice. When fitted it is to be soldered in place, immediately over the slit in the barrel. In this and subsequent operations of soldering the joints are to be "sweat" together, that is, the pieces are bound in place with wire, plumbers' acid and solder put around the joint, and the whole heated in a lamp until the solder flows into the joint, when it may be "wiped" with a piece of cloth. Thus is formed the standard of the instrument, which serves to support it upon its base. To this end a plug of wood may be driven firmly into the open end of the standard, and a large screw passed up through the base into it, thus binding the two together. The base may be turned or finished in any form to suit the taste of the maker, and it should be provided with 3 levelling screws threaded through the base itself or through projecting arms of brass.

At the central point of the top of the barrel drill a small hole, and over the hole solder a brass ferrule for holding a glass tube, which last is to carry the suspension arrangement. Now take your piece of 3-in. tubing again and saw from it two rings, each ¾ in. wide. After smoothing the ends of these, slit them open and take out a small portion, so that they may just be sprung into the barrel. While in this position, with a little projecting, one of the discs is to be laid upon either ring and secured by soldering. Thus are formed two shallow cups for containing the coils. Through the centre of one of these cups make a hole ¾ in. diameter, and also in each cup two fine holes, one near the circumference, the other near the centre, for passing out the terminals of the coils. In the cup having the large central hole, the small hole is to be made close by the edge of the large one.

The coils themselves may next be wound. Make a spool of wood, 1 in. between the heads, and having its core ¾ in. diameter at one end, ⅝ in. at the other. The spool head on the smaller end of the core is made removable, so that the coil when finished may be drawn from the spool. Pin the spool to any convenient support with a large screw, and insert a peg near the margin of the free head, to serve as a handle for turning the spool in winding the coil. The wire to be used will depend upon the purpose for which the instrument is to be employed. Nos. 24 to 28 wire is good for general purposes; but the general worker will find it advantageous to have three sets of coils of Nos. 16, 28, and 36 wire respectively, and it was that other cups and coils might be made at leisure that the extra tubing and discs were provided.

Before winding, the wire is to be cooked in hot paraffin until all air is driven off. Make a small hole through the spool head close to the larger end of the core, pass one end of the wire through this hole, and then, guiding the wire with one hand and turning the spool with the other, fill up the spool, making the winding as snug and perfect as possible. To permit of adjustment, the outer diameter of the coil should be a trifle less than the diameter of the cup that is to contain it. Carefully take away the removable spool head, and without disturbing the coil give it a thin covering of *solid* shellac upon its exposed face and edge. The shellac is melted, and neatly smoothed upon the coil with a hot iron. The coil may now be most carefully removed from the spool and its other face, as well as the portion within the conical hole, coated with shellac as above. The second and subsequent coils are made in the same manner. The coils are fixed in the cups by pouring melted rosin about them, first taking care to pass the terminals through the holes provided for them.

The needle or magnetic system next demands attention, and it will test the skill of the beginner. A piece of No. 16 aluminium wire, 3 in. long, is flattened at either end for ½ in. of its length, and through one end a minute hole is pierced. A staff for carrying the magnets and mirror is so formed. For the magnets procure a rather wide watch spring, anneal it well, and file or grind a portion of it until it is made as thin as newspaper, about ·07 mm. Cut from this 12 pieces, each ⅜ in. long, and roll them about a steel wire into little hollow cylinders $\frac{1}{25}$ in. diameter. (Some manufacturers use short flat pieces of narrow watch spring for this purpose.)

The 12 cylinders are then to be dipped in a strong solution of potassium ferrocyanide, heated to bright redness, and suddenly plunged into cold mercury. By these means they are made extremely hard, and will retain a very strong magnetic charge. To magnetise, string them on a wire, and put in a solenoid through which the strongest available current, preferably that from a dynamo, is made to pass.

On little square scales of mica arrange the magnets in two sets of 6 each, taking care that in each set the poles of the individual magnets shall lie in the same direction. Secure them upon the mica scales with a very little shellac varnish, and in the same way the mica scales upon the staff, one at either end, being very careful that the combined poles point in opposite directions in the two sets of magnets. In front of the magnets near the upper end of the staff (the end having the minute hole) is placed a mirror, and fixed with shellac. These mirrors may be bought for a small sum of the dealers, or easily made by grinding very thin a piece of plate glass and silvering its unground side. The ordinary microscopic cover glasses are rarely perfect enough to be used as mirrors. Our needle now needs only the addition of a pair of dragon-fly wings, in the position indicated in Fig. 200, to make it complete. These wings bring the needle quickly to rest after a displacement.

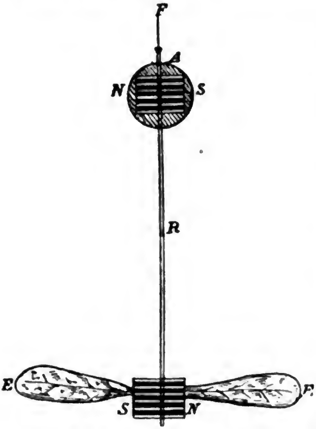

FIG. 200.—Galvanometer Needle.
R, aluminium wire; A, mirror; N S, magnetic system; F, silk fibre; E E, dragon-fly wings.

A glass tube, 10 in. long, is now to be fixed upright in the ferrule on the top of the barrel. A litle sulphur melted upon the heated end of the tube accomplishes this. The top of the tube must be provided with an arrangement for suspending the needle. Fig. 201 shows how this is made.

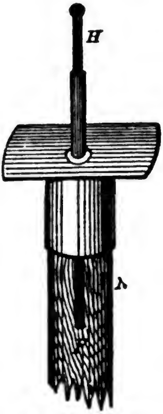

FIG. 201.—Suspension.
H, sliding wire for adjusting needle; F, silk fibre; N, glass tube.

Another ferrule fits the glass tube. On it rests a small plate of sheet brass, which is perforated, and through the latter a split tube passes, grasping a wire, and moves in the tube with gentle friction. The ferrule, the plate and the split tube are united with solder. To suspend the needle, remove the sliding wire and to its extremity attach with varnish one end of a long fibre of silk, such as may be drawn from white embroidery silk or a white silk ribbon (unspun silk fibre is preferable for this purpose, but the twisted fibre may be straightened by steaming). Press a little ball of wax upon the free end of the fibre, and drop the ball down through the split tube into the galvanometer barrel, and push the wire in place. The end of the fibre in the barrel can now be caught and threaded through the hole in the needle staff, secured, and the wings put through the slit at the bottom of the barrel, where they should swing freely in the tube below. The coils can now be pushed into place, the coil having the large hole being the front one. In this hole a spectacle lens of 4 ft. focus, ground to a fit, is to be cemented. The suspension wire is moved up or down until the mirror is seen to occupy the centre of the coil. Two of the coil terminals are to be joined, so that the current may circulate in the same direction in each coil, and the other two are connected to screw posts upon the base of the instrument.

A small bar *controlling magnet* is provided, either upon a separate stand, or it may be attached to the glass tube with the aid of a split cork. The instrument itself is now complete, except some means for reading its indications. The following simple device accomplishes that purpose better than the most elaborate and costly telescope and scale. Procure one of those lenses sold as reading-glasses. It should be about 3 in. diameter and 6 in. focus. Make a stiff tube of paper 2 ft. long, 3 in. internal diameter. The tube should be furnished with a telescopic slide at one end, and in the slide a peephole. The lens is to be fixed in the tube at its own focal distance from the peephole, and opposite the peephole, also in focus of the lens, a fine wire or spider line is stretched. Fig. 203 shows the device in section and will make the details clear.

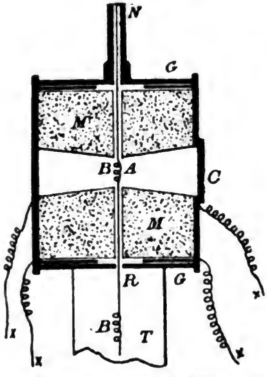

FIG. 202.—Section of Galvanometer.
G G, galvanometer barrel; M M, coils; A, mirror; B B, magnetic system; C, lens; T, tube for standard; N, glass tube; R, aluminium wire; X X, terminals of coils.

A scale of equal parts printed or marked upon paper and attached to a strip of board is the only remaining detail. The telescopic device is secured so as to point directly at the galvanometer mirror, about 6 ft. distant, and a few trials will enable one to place the scale so that a distinct view of the divisions may be had upon looking through the telescope. Remember that the scale is seen reflected in the swinging mirror, and there will be but little difficulty in securing the correct adjustments.

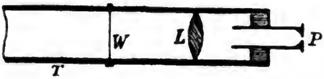

FIG. 203.—The Telescope.
T, paper tube; P, draw tube; L, lens
W, wire.

An instrument made by the writer in the foregoing manner, though it has a resistance of only 50 ohms, gives a deflection of 20 divisions of its scale through a resistance of 250,000 ohms, the current being furnished by a single Daniell's cell. It can be made without a lathe. There is but a single screw about it, and the whole cost of construction need not be more than 10*s.* to 12*s.*

* * *

GAS FITTING.

(*See also* ACETYLENE PLANT.)

(*a*) BEFORE the introduction of the incandescent systems of gas lighting, the advantage of gas for illuminating purposes would only bear comparison against oil lamps, but with the incandescent burner there are advantages that compare favourably against the electric light for many purposes. As against oil lamps gas is cheaper for a given degree of illumination; it is cleaner, and gives no odour; the breakage and wear and tear to the fittings are less; the labour of attention is almost totally absent, danger is reduced; and, in the case of large rooms or public places, something more effective than oil becomes absolutely requisite. As against electric light, gas has few advantages of course, but there is little doubt in any one's mind that, with incandescent burners, the cost of the light obtained is much less, and the maintenance is generally in favour of the gas. With ordinary care the renewal of gas mantles costs less than the periodical renewals of the electric incandescent lamps; this being particularly the case with bye-pass burners. The electric light does not, of course, vitiate the air, nor does it discolour ceilings and decorations. This has been strongly urged in its favour, but it no longer makes the strong impression it did previous to the incandescent gas burner being introduced.

The tapping of a gas main and providing the service between main and house is done by the gas company whose district the house is in, but as this work is sometimes let out, a description of the method employed is given. There are advocates for drilling the hole in the main, while others consider it best to cut it with a chisel, as the latter is quicker and involves less preparation and fewer tools. In drilling, the hole is bored of a right size for tapping, while with a cut hole the size should be a little smaller to allow of its being rimed out afterwards. The tapping is then done, and a bend (with its socketed end plugged) is immediately screwed in. Leakage of gas as the work proceeds can be lessened by the use of a little clay around the tools, or, with the tap, a little stiff grease in the flutes will do. If the service is to supply a large building, and requires to be of a size that cannot be tapped into the main, then the main must be cut and a cast tee inserted. To effect this there have to be measures adopted to prevent gas escape, and the work is consequently done as follows:—

The main is first tapped at two points well beyond where the pipe is to be cut, and between these two points a bye-pass is fitted, as shown in Fig. 204, of 1-inch pipe. This is to provide a supply of gas along the main while the work is in progress. A little way inside each connection of the bye-pass two smaller holes are drilled, and the edges of these holes are nicely cleaned off, as an india-rubber bag has to be passed through each and inflated as shown. When this is done gas cannot pass direct along the main, and it is possible to cut out the piece, where marked in dotted lines, without a serious escape occurring. The tee-piece is then inserted with a loose sliding socket, as shown at Fig. 205, all sockets being well caulked, first with yarn, then with lead, in the usual way. After plugging the tee (or running the service) the bags and bye-pass are removed and the holes plugged.

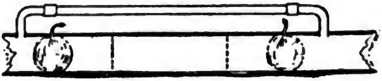

FIG. 204.

The service from the main must be carried in an ascending direction towards the house, giving the pipe the best possible rise, so that whatever water may be condensed in it will flow back to the main. In circumstances, however, in which the main is some distance away and not deep down then it may be better to let the service descend towards the house, in which case a drip pipe is provided (by means of a tee-piece and a short length of tube) for the condense water to collect in, and this is periodically emptied by the cock or plug, whichever it is provided with.

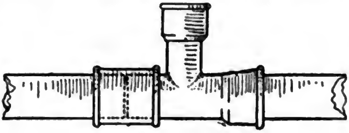

FIG. 205.

Occasionally the gas service may have a large drain or other pipe bar its direct passage to the house, and it then becomes necessary to rise over it, so that there occurs a fall to the house and a fall to the main, as shown on right side of Fig. 206. The drip pipe* is then necessary as shown, but an ingenious way of passing the obstacle without a fall to the house is shown on the left side of the drawing. This needs no explanation. Service pipes must be well supported by blocks resting on the bottom of the trench—not on the earth filled in—and it will pay the fitter to see the filling in is done properly. The main cock comes on the service directly it enters the house, but on the meter side of the drip pipe if the latter is provided.

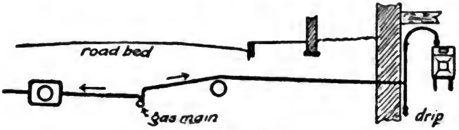

FIG. 206.

The meter is usually placed in a cellar within about 2 feet of where the service terminates, and, except in the largest sizes, the connections are by lead pipe. This pipe admits of the work being done easily, and causing no strain on the parts of the meter afterwards. It should be nicely bent, and must not dip to form a pocket for condensed water. If the cellar is a very cold one, it is well to cover the service and its connection, as water vapour can have its particles freeze and stop a pipe, even though the service has a proper fall back to the main. The sizes of the connections to meters are as follows, the inlet and outlet being of the same size. The meters can have 25 per cent. more lights on them than they are marked.

Meter.	Inlet and Outlet.	Meter.	Inlet and Outlet.
5 light	½ inch	80 light	2 inch
10 ,,	¾ ,,	100 ,,	2½ ,,
20 ,,	1 ,,	150 ,,	2½ ,,
30 ,,	1½ ,,	200 ,,	3 ,,
45 ,,	1½ ,,	400 ,,	4 ,,

It would be better never to use less than ¾-inch pipe for the service from main, however small the number of lights and the meter may be.

In the piping of a house there is comparatively little skill needed, except to remember that water will condense out of the gas supplied, if it becomes cool enough, and in every case care must be exercised to dispose of this. The pipes must have a fall to the meter wherever possible, and in the case of moderate and fair-sized jobs, there should be a drip pipe or siphon on the house side of the meter to receive the condensed water from the house piping. Where it is impossible to give a branch a fall towards the meter, then the next best thing is to give the fall to a chandelier or pendant which contains water. If this is impossible, then drip siphons must be provided at other points, as convenient of access as possible. It is to meet difficulties of this kind that the piping is so much the best if done while the house is in a skeleton condition.

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* The drip is very commonly called a syphon, which it in no way resembles.

The piping of a house must always be tested, and if it is in a new building, it is well to get the architect to see the test, and be aware of the soundness of the work. Before the house is finished, the carelessness of other trades may make a difference which is not discovered until all is covered over, and then the gas fitter is blamed for unsound work. The testing can be done with a force pump if the gas is not on, but if the gas supply is connected, a good test can be made by watching the meter. There is a small dial on the meter that will plainly show the passage of a fraction of a foot of gas, and if a burner is lighted until the pointer is dead on one of the division marks, and then turned off, a quarter of an hour will be sufficient to show if there is a leak by the further movement of the pointer, if it moves at all. The pointer will not move with all the burner taps closed, unless there is a leakage at some point. A leak may not necessarily be in the fitter's work, it may be in a bracket or fitting, but it has to be found and stopped. A common and well-known leak that may occur at some period after the work is finished, is that caused by nails being driven into lead or composition pipes. Compo pipe is largely—too largely—used in small houses, or cheap work of any magnitude, being buried in plaster, also run under floors; it is almost impossible to locate the pipes with any exactness, in fact, their existence may not be thought of by those driving the nails. It is better to use iron pipe, and with this there is no risk of sagging and less likelihood of water collecting anywhere.

The jumping of lights may be said to be always due to water in the pipes, and this being in almost every case the result of careless work. Sometimes, however, the jumping at a chandelier is due to a leak in the inner tube (which gets eaten away) allowing water to get into the arms and interfering with the passage of the gas. To remedy this the leaky place can be soldered over, but to do this usually entails so much work in getting at the leak that it is well to put a new tube in at once and save a probable repetition of the trouble with the old tube.

A governor should be considered a necessary adjunct to every system of gas piping where the pressure of gas may vary by reason of the number of lights burning at one time being irregular, or from any other cause which may make a difference in the rapidity of issue of the gas. Even in moderate sized residences the governor can be recommended, and will prove economical as well as a convenience. To illustrate by an extreme case, suppose there were fifty lights in a building, and at times only ten or twenty were in use while the full pressure of gas was on. This would necessitate regulation at the taps or elsewhere, or a waste, with indifferent lighting qualities, would occur. Or, again, it will be noticed that the gas companies increase the pressure of gas in the mains as darkness comes on, and this increase, in many cases, causes lights to increase or flare, and use more gas without any advantage. A governor controls this, as it is an automatic regulator, almost an automatic main cock, except that it is not intended ever to shut off the gas supply entirely, only control it. Fig. 207 illustrates, in section, the principle of a Fletcher's governor; and it may be noted that all makes of these appliances will admit of regulation, to suit the gas pressure in the first place.

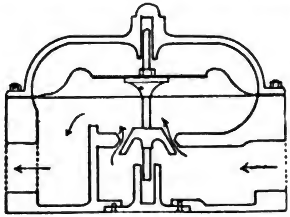

FIG. 207.

Stott's governor is also a good and well known make; but nearly every firm of gas engineers of importance will be found to have a governor of their own design.

(*b*) *Connecting to Compo Pipe.*—This is an eminently simple operation, capable of being performed by any one who has had any practice in soldering joints. It consists merely in making connections between a series of iron and "compo" pipes and the "burners," as well as fixing the latter. The ordinary arrangement of the gas supply of a house is as follows. An inlet pipe of iron brings the gas from the street main to the meter. This latter belongs to the gas company, and is of a size to supply a certain number of burners. It is placed in an out-of-the-way situation, generally a cellar, as near the street as may be. From it an iron pipe passes up to the level of the first floor requiring a supply of gas; here branch pipes are led off to the various rooms, while the principal pipe is continued upward through the other stories as far as desired.

The mode of procedure is first to fix the burner in place, and then to lead a pipe from it to the nearest point on the supply pipe, and there to make a joint. Burners may be broadly classed in two divisions—brackets and pendants; the former are placed against a wall, the latter hang from a ceiling. In choosing a situation for a bracket, care must be taken that it does not reach any movable article of an inflammable nature, e.g. curtains, cupboard-doors, etc.; in the case of a pendant, the chief care will be to let it be out of the way of persons occupying the room; of course there is a great variety in both brackets and pendants, but this has no influence on the mode of fixing, except in the case of the chandelier with universal joint.

Commencing with a bracket, as being simplest, a spot on a wall having been chosen for its site, the first step is to prepare the wall for its reception. The pipe to supply the bracket should be carried as directly and as secretly as possible to the main supply, which may be in the ceiling above the room, or in the floor beneath it, or in the wall of an adjoining room or passage. Secrecy is secured by chiselling out a small recess in the brick wall sufficient to admit the pipe, carrying it behind skirting-boards, or in angles where it can be papered over, and in other ways that suggest themselves according to the circumstances of the case. Everything being ready for laying the new pipe, one end of it is soldered to an "elbow nose-piece" or piece of ⅜-in. brass tube, bent at right angles, tinned ready for soldering at one end and having a screw-thread on the other, as shown in Fig. 208, *a* being the elbow nose-piece and *b* the soldered joint. Whilst the pipe is held securely in place, the mahogany block *c* is slipped over the nose-piece, and nailed, screwed or plugged to the wall *f*, leaving the thread end of the nose-piece projecting. Having well luted the thread with white-lead, proceed to screw on the bracket *d* till its flange *e* is tight against the mahogany block, when it is fastened there by 3 screws. Be very careful that the joint between the bracket and the nose-piece is a good sound one. The burner being fixed, it only remains to lead the pipe away to the main supply, and solder it on by means of a union suited to the case.

In hanging a pendant, the supply pipe is brought between the joists of the ceiling of the room, as in Fig. 209, where *a* are the joists; *b*, the floor of the room above; *c*, the ceiling; *d*, a piece of board nailed to the joists *a* for supporting the mahogany block *e*; *f*, the supply pipe; *g*, a straight nose-piece, carrying a thread, on which the pendant is screwed as before. The pendant may either be a stationary one incapable of being moved in any direction, or one having a swing or ball joint. Care must be taken during the fixing of the pendant that it does not rest its unsupported weight on the nose-piece *g*, or there is danger of straining the joint between *f* and *g*.

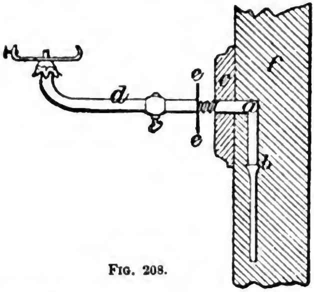

FIG. 208.

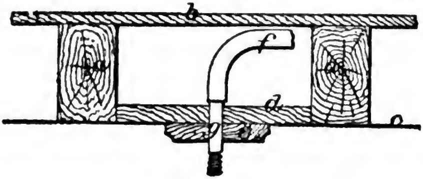

FIG. 209.

Chandeliers being much heavier are attached to iron pipe instead of the weak compo tubing used in other cases, and this iron pipe is allowed to rest across 2 joists, in notches cut for the purpose, as Fig. 210. A short section of iron pipe, attached to the supply by a T-piece, comes sufficiently far through the ceiling for the cup and ball of the chandelier to screw on to it.

(*c*) Coal gas, being much lighter than air, flows with greatest velocity in the upper floors of houses; hence the supply pipe may diminish in size as it rises, say from 1 in. at the basement to ½ in. on the third floor. At a point near the commencement of the supply pipe it should be provided with a "siphon," which is simply a short length of pipe joined at right angles in a downward direction and closed at the lower end by a plug screwed in. As all gas-tubes should be fixed with a small rise, this siphon will collect the condensed liquids, and these may be drawn off occasionally by unscrewing the plug end. When the lights flicker, it shows there is water in the pipes, and this can be run out from the siphon.

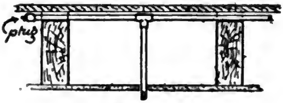

FIG. 210.

The number of gas burners requisite for lighting a church or other large building may be computed thus. Take the area of the floor and divide this by 40, will give the number of fish-tail burners to be distributed according to circumstances. Example: a church 120 ft. long by 60 ft. wide. contains 7200 ft. area; divided by 40, gives 180 burners required for the same.

Some people consider that burning gas without a ventilator or pipe to carry off the effluvia, is almost as bad as making a fire in a room without a chimney to carry off the smoke. If a pipe of 2 in. diameter were fixed between the joists, with a funnel elbow over the gaselier, and the other end carried into the chimney, it would be a general ventilator. Of course, an open ornamental rosette covers the mouth of the tube; or an Arnott valve ventilator over the mantelpiece would answer the same purpose.

In turning off the gas-lights at night, it is usual, first, to turn off all the lights, except one, and then turn off the meter main cock, and allow the one light to burn itself out, and then turn it off. The evil of this system is this—by allowing the one light to burn itself out, you exhaust the pipes and make a vacuum, and of course the atmospheric air will rush in. The proper way is to turn off all lights first, and finally the meter, thus leaving the pipes full of gas and ready for relighting.

Clustering of gas lights is bad. All parts of a room should be as nearly as possible equally lighted, the only noteworthy exception to this rule being in the case of a dining-room, where concentration of light upon the table is not only permissible but is even demanded. Hence in most cases wall brackets give the best effect, and such masses of lights as are afforded by pendants of many arms are to be avoided, or are only required in very large rooms where portions of the floor area would otherwise be insufficiently lighted If care was only used to see that burners were properly distributed, many a dimly-lighted apartment would be perfectly illumined with the same number of burners, which, when massed appear insufficient.

Where concentrated ceiling lights are needed for dining-rooms, many-armed pendants are seldom satisfactory, owing to the shadows which most of them cast. In these cases a single powerful argand or incandescent burner in a suitable reflecting pendant, or a cluster of flat flames similarly provided, will give a better result than the usual branched chandelier, and with a material saving in gas. For it is a curious and valuable property of gas, that large burners can be rendered much more economical in proportion than smaller ones. Thus, if the 4 burners of a branched chandelier give altogether the light of (say) 50 candles, the same illuminating power may be obtained from a greatly reduced quantity of gas when concentrated in a single burner of an improved kind.

With regard to flat flames, which are still largely used for ordinary room lighting, the selection of glass globes is a very important matter. It may be said at once that all the old-fashioned style of glasses, with holes in the bottom about 2½ in. diameter, for fitting into the brass galleries of the older pattern pendants and brackets, are objectionable. The reasons for this condemnation are few and simple. It seems never to have occurred to the makers of these things that the gas flames inside the globes are always wider than the openings beneath them, through which the air required for combustion passes; and that, as a rule, the light of the flame is required to be cast downward. Gas flames always flicker in these old-fashioned glasses, because the sharp current of entering air blows them about. And the light cannot come downward because of the metal ring and its arms, and the glass, which is always thicker and generally dingier at this part of the globe. Perfectly plain and clean glass absorbs at least $\frac{1}{10}$ of the light that passes through it; ground glass absorbs $\frac{1}{3}$; and the ordinary opal obstructs at least $\frac{1}{2}$, and generally more. Only those globes should be chosen therefore which have a very large opening at the bottom, at least 4 in. wide, through which the air can pass without disturbing the flame. The glass then fulfils its proper duty, screening the flame from side draughts, and not causing mischief by a perpetual up-current of its own. Good opal or figured globes of this pattern may be used without disadvantage, because the light is reflected down through the bottom opening more brightly than if there were no globe, while the flame is shaded and the light diffused over other parts of the room.

* * *

GAS HEATING APPLIANCES.

GAS fires, and water heaters using gaseous fuel, are now being used in great variety and greater number; yet, at the time of writing, although gas companies and tradesmen deal most largely in these goods, the care needed in fixing is not made as prominent as it should be. These appliances are a source of great convenience, and they have reached an eminently practical stage, yet quite recently the founder of one of our greatest technical institutions was poisoned (or asphyxiated) while bathing in a room where there was an improperly fitted heater. The list of less important people who have met death in this way is really large, yet the gas appliances are perfect and safe if the fixer uses but ordinary care or intelligence in the fixing. What has to be impressed on fixers or intended users of gas fires, is that they must be fixed and connected in an effective manner, and the conditions under which they are required to work must be favourable and conducive to efficiency and safety.

To make the meaning of this last statement clear, take the very common case of people resorting to a gas fire because a chimney is defective and will not admit of a coal fire being enjoyed. The chimney probably has a down-draught in certain weathers, causing the smoke from a coal fire to be driven into the room and rendering it uninhabitable, besides damaging furniture and decorations. In such a case a gas fire may be fixed up in front of the fire-place, and, strange as it is, when an odour of sulphur is perceived and the occupants of the room have headaches or other disagreeable symptoms, they either attribute the trouble to something else or they blame the construction of the gas stove. It is strange that there should be such a popular notion that the substitution of a gas fire for a coal fire causes the chimney to cease its inefficiency. Of course it does not, and the down-draught (or whatever trouble it might be) continues just the same.

The real difference in results between a gas and a coal fire with an ineffective chimney is, that with the latter the annoyance is of a very pronounced visible character; but the products of combustion from gas being invisible, mislead people into thinking they are absent, or that they can put up with them. Let it be clearly understood that the action of a defective chimney is precisely the same with one kind of fire as the other; and although the products from a coal fire, when driven into our rooms, are the greatest source of annoyance, the products from a gas fire are a greater source of injury and of real danger to the human system. With a gas fire working under these conditions, we, in effect are served almost as badly as if we had a coke or charcoal fire burning and admitting fumes (products of combustion) into the room now and again.

It is essential for health and comfort that a gas fire be connected with a chimney, so that all products of combustion pass away and in no way mix with the air in the room that we breathe. To effect this it is absolutely necessary — and this cannot be too strongly insisted upon — that the chimney be normally effective. Any idea that the installing of a gas fire will remedy a defective chimney is incorrect, and occasionally has an element of danger associated with it. Let this, please, be information also to those (and their number is many) who consider a gas fire does not require a chimney at all. Occasionally it is permissible to use a gas fire without a chimney, but such occasions are few. An instance would be that of a shop with doors constantly opening, and abundant ventilation; but in such a case only a small gas fire could be tolerated with any degree of comfort. If we take the reverse of this, and put a gas fire into a bath room without a chimney, the act would be positively suicidal, as the products of combustion are highly poisonous and conducive to asphyxia.

Although dwelling so long upon the subject of chimneys, a word must be addressed to those (and here again the number is many) who, fully believing a chimney is necessary, consider that a piece of pipe thrust through a hole in the wall will do. This is an erroneous idea, quite upon a par with the last described. Briefly, a chimney to be effective must be carried as high, and a few feet above, the topmost part of the house, and this applies whether the fire burns coal or gas. It is next to impossible to carry a pipe chimney right up the house, so some means is adopted to connect the gas fire with an existing brick chimney, and this latter must be of normal efficacy.

Next in importance to the troubles and dangers brought about by inefficient chimneys is the liability of gas fires to "light back." By this is meant ignition of the gas at the point where it first enters the stove and where it mixes with air in what is called an atmospheric (or Bunsen) burner. It will be found in all gas heaters—excepting the few that burn with a luminous flame—that the flame itself is blue, and this is due to the gas mixing with atmospheric air in a mixing chamber or bulb below or at the back of the stove. The trouble now being referred to is a habit some fires seem to have of igniting the gas in this chamber, and therefore failing to burn properly in front where the flame and heat are required.

This may be due to several causes, such as poor pressure or supply of gas, down-draught in the chimney, or, more probably, too small a gas service pipe. Formerly the gas-fire makers gave no instructions as to what sized service pipes were needed for their different sized stoves, but they do now; but, notwithstanding this, a common practice prevails of making the connection or part of it with a very small-sized rubber tube.

What both fixers and users have to be cautioned of, is the danger that exists with a stove given to "lighting back." It is not a question of combustion products or of unburnt gases escaping; but that when the gas ignites at the point in question the heat will cause rubber or soft metal tubing to melt, with most deplorable results in some cases. The gas service connection is always close by where this ignition occurs, and it follows that the metal at that point must get very hot. The heat, by the rapid conductive properties of iron or brass, is at once transferred to the indiarubber or compo tube, causing it to fuse or melt. Gas immediately escapes from the fused tube, ignites and quickly melts this material back as far as it can. This burning and destruction of the tube will probably bring the flame in contact with woodwork, and the result of this needs no describing.

This is, perhaps, an alarming way of showing what may happen with a gas fire improperly connected, yet everyone who has had experience of these articles must endorse what has been said. The writer has experienced the dangers of rubber tube, but with no worse effect than a little injury to paintwork. Thousands have undoubtedly had something similar occur, and no hesitation need be felt in saying that injury to buildings by fire, to a more or less serious extent, has commonly occurred from this cause. The remedy is to have gas-fire connections made with iron, brass or copper tube, with screwed or brazed, but not soldered joints. Briefly stated, a gas fire need be no cause for fear or alarm in any way if it is connected with these hard-metal tubes, and works in conjunction with an efficient chimney. It is only these two points that the people have to be cautious about. If they exist as recommended, there may still be the annoyance of "lighting back" (due to other causes, and which can be remedied), but there will be no danger.

It is very doubtful whether the gas fire will ever supersede the coal fire entirely. There are many agreeable associations with the latter, and as matters stand at present, this latter is certainly the least expensive for given results. In certain cases, however, and particularly for sleeping apartments or bath rooms and the like, gas fires display their utility to great advantage, and much can be gained by their use if judiciously placed. There is just one disadvantage that these gas appliances have at present (but which doubtless will be remedied before long), in the fact that the heat cannot be regulated at all well. If the gas tap is turned down, "lighting back" will most probably occur, and this particularly if the flame is fanned by any little draught. This is due to the burners being made in such a manner that when the gas supply is reduced the entry of air into the mixing chamber is not shut off in proportion. This fault is particularly noticeable when a gas fire of too large a size is installed, and the heat it evolves greater than is comfortable. It is a little surprising that gas-stove makers have not overcome this fault, as it presents no great difficulties. Probably some may have done so, but certainly they make little use of it, and their catalogues make no profession of such an improvement.

The difficulty of disposing of the dangerous products of combustion is most pronounced with the rapid water-heaters, called "Geysers." This is because the geyser is almost always wanted in a bath room, and the average bath room does not have a chimney to it. It is the geyser that has brought about a number of fatalities, not because it is a dangerous apparatus but wholly because of the ignorance of the fixers. At the present time each geyser has printed explicit directions regarding the fixing sent with it, and this has tended to overcome all risks.

In the fixing of a geyser the gas service pipe should be of hard metal, the same as with a gas-fire, and it should never be of a smaller sized pipe than the connection provided on the appliance. The chief care lies in disposing of the products of combustion. These must *never* discharge into a bath room. Such rooms are always small—too small to receive these products and yet have an atmosphere safe to breathe—therefore the first thing to be done is to see if a chimney is available to convey the products to. If there is a fireplace and chimney in the bath room then this, of course, will serve best; but, if not, it must be seen if a chimney in another room can be made use of. Assuming a chimney is available, it is important to see that its up-draught is normally good, so that the products from the geyser will be taken quite away freely and positively. There must be an active and permanent up-draught in the chimney. In connecting the geyser to the chimney sheet-iron pipe will serve, but the joints, where the lengths come together, must be made sound and air-tight. At the point where the pipe joins the geyser, also where it joins the chimney, it must be made quite sound and air-tight also. In other words, the same care must be used as if it was a smoke pipe and the geyser depended on the draught for its efficient working as a coal stove would.

If it is not convenient or possible to have the geyser in the bath room and connect it with the nearest chimney, a thought must be given as to whether the geyser can be put in another room where a chimney is available. This can be done with many geysers regardless of levels, though with several the delivery of water from the geyser can only be in a downward direction.

Assuming neither of the fixings already suggested to be possible, another course is open, this being to have the geyser in the bath room (or wherever preferred) and then take the flue pipe up from it and terminate it in a roof space. The products of combustion discharged into a roof space should do no harm, and they will work away through the openings there without being a source of risk or trouble. Should this plan be adopted it would be wise of the workman to see that the draughts in the roof (especially if not boarded and felted) cannot cause down-blow in the pipe, and he must use his judgment to see that the arrangement is one that has sufficient prospect of being effective. (F. Dye.)

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GAS MANTLES.

THE INCANDESCENT GAS MANTLE.

THE following information formed the subject of a series of Cantor Lectures delivered by Prof. Vivian B. Lewes, before the Royal Society of Arts, and is reproduced by the Society's permission.

Producing light by heating refractory bodies to incandescence is entirely an outcome of the 19th century, and dates from 1826, when Drummond first showed that a piece of dense lime could be raised to intense incandescence by the heat of the oxy-hydrogen blowpipe flame, the lime at later dates being replaced by buttons or discs of magnesia and also by zirconia. When using a comparatively large mass of material, as was done in these earlier experiments, the temperature needed to secure incandescence was above that which could be obtained by the use of air as the supporter of combustion, and it was a considerable step forward when it was realised that by attenuating the body to be heated, and choosing a highly refractory material of low conductivity, an ordinary flame could be made to give the temperature which with the larger mass had required the use of such costly appliances as the oxy-hydrogen blowpipe.

Even before the middle of the 19th century the general principles upon which the incandescent mantle of today is based were known, for we find that Talbot, in an article on "The Nature of Light," published in the 'Philosophical Magazine,' in 1835, stated that "Paper soaked in a solution of chloride of calcium, and burnt in the flame of a spirit lamp, leaves a white network of ashes, which, when held in the feeblest alcohol flame, emits a brilliant light."

This experiment contains the germ of incandescent gas lighting, and embodies the principles adopted at the present day, namely, the saturation of a natural combustible fibre with the salt of a metal, burning off the organic matter, and leaving a skeleton of the oxide of the salt of the metal used, in so finely divided a condition that when subjected to the heat of any ordinary non-luminous flame it becomes incandescent.

Four years afterwards Cruickshank took out a patent for a cage or mantle of fine platinum threads woven together, and of such a shape and size as to thoroughly envelop the outer portion of the flame which causes its incandescence. Cruickshank, however, noticed that the luminosity of the wire was not so great as that emitted by heating the oxides of certain metals, and attempted to increase the light emissivity by coating the platinum wires with a paste of such oxides, but without much success, as it was found impossible to make the paste adhere to the surface of the wires for any length of time.

In 1848, Gillard first put the manufacture of water-gas on a comparatively successful footing by introducing the principle of raising carbonaceous material to incandescence in a cupola furnace by an air blast and then injecting steam to form the water-gas until the temperature fell, when the steam was cut off and the fuel again "blown" up to the necessary temperature to make water-gas once more, a process which is the basis of all modern water-gas practice.

Water-gas, consisting of nearly equal volumes of hydrogen and carbon monoxide, burns with a non-luminous flame; and, desiring to utilise it for lighting purposes, Gillard devised a cap or mantle of fine platinum wire, which was suspended in the flame and heated to incandescence. For some months this method of lighting was in use at Passey and Narbonne, but the trouble which has wrecked all attempts to utilise mantles of platinum soon showed itself, and the light emitted by the metal filaments rapidly grew less and less under the influence of the burning carbon monoxide, and finally the mantles became so brittle that they fell to pieces.

In 1849, Frankenstein introduced a lamp in which the flame from oil or spirit was caused to heat to incandescence a netted fabric, which was coated with a thin paste of magnesia and lime mixed with gum arabic. Owing, however, to the materials being merely pasted upon the fabric and not soaked into it, these mantles were very fragile and had no durability. Indeed, it is an impossibility to make a mantle exactly according to the instructions given by Frankenstein, who, as was afterwards explained by Werner, really mixed with his ingredients a little common salt, whereby some of the oxides were converted into soluble chlorides. These soaked into the fabric and so rendered the manufacture of the mantle possible.

So far the work done had been to establish the form of the mantle, and the principle of obtaining the material in a sufficiently fine state of division to become highly incandescent at the temperatures given by an ordinary flame, whilst Talbot had clearly indicated the way in which this might be done.

The only non-luminous flames available up to this period were those of the spirit lamp and water-gas, but at this epoch Bunsen, the greatest of Heidelberg's great men, was planning and fitting those laboratories which have since then given so rich a harvest to the scientific world; and, while considering the methods of heating which should be adopted on the working benches, his attention was called by one of his assistants—now Sir Henry Roscoe—to the then novel contrivance of a non-luminous gas burner. Seeing at once the enormous convenience of such a source of heat, Bunsen brought his marvellous manipulative skill to bear upon the subject, and in a few weeks gave the world the "Bunsen burner"—a burner which has done more for the gas industry than almost any discovery or invention connected with it, which has made coal-gas available for fuel purposes, and has enabled it in conjunction with the incandescent mantle to hold its own against the threatened rivalry of the electric light.

The next step of importance in the history of the incandescent mantle was the replacement of lime and magnesia, which up to this time had alone figured as constituents of the attempted mantles, by oxides of a more refractory character, having the property of emitting a more intense light at the available temperatures.

In 1852, Bergemann noticed that oxide of thorium when heated to incandescence emitted a beautiful light, while in 1863 Bahr, when heating nitrate of erbium upon a platinum wire, observed that it swelled up and left a residue of oxide, which emitted a brilliant greenish light. He communicated this result to Bunsen, and they made a joint investigation of the subject, the results of which were published in Liebig's 'Annalen' for 1864, where they pointed out that the oxides of the yttrium group of metals, when heated to incandescence, emit a beautiful light of great intensity.

In 1878, Edison patented the idea of coating platinum wires with oxides of such metals as zirconium and cerium, the materials being applied as soluble salts, acetates, oxalates, or nitrates, which were then burnt off, giving a more coherent structure than was obtained by Cruickshank; the coated wires were afterwards heated by the passage of an electric current. It is evident, therefore, that by 1878 not only had the principles upon which the mantles of to-day are constructed been published, but the oxides of the rare earth metals had been recognised as incandescents.

In England the first practical attempts at incandescent lighting were in the early eighties, when the Lewis incandescent platinum mantle and the Clamond incandescent light were for the first time brought to the notice of the public. The Lewis mantle consisted of a cylinder or cone of fine platinum wire gauze fixed to the end of a Bunsen burner, the gas being supplied at ordinary pressure, whilst a current of air was forced at a considerable pressure up a central inner pipe, the injecting action of which also caused an additional supply of air through lateral supply pipes.

These mantles were never a great success. The necessity of using air under pressure was a serious drawback, but the most important objection to them was that the surface of the platinum was slowly corroded by the burning gas; and though the mantles yielded a very good light at first, the luminosity rapidly decreased to a very low point.

In the Clamond mantle a conical basket of threads of calcined magnesia was employed, being supported in a small platinum cage point downwards, and the flame was driven into it from an inverted burner above. These baskets were formed by moulding a paste of hydrate and acetate of magnesia mixed with water, into threads which were then woven into basket form and ignited. In this system the gas and air were at first used under pressure, but in the later forms the basket was converted into a mantle by supporting it with its apex upwards, and an ordinary burner of the Bunsen type was used to heat it.

The above mentioned processes and researches really represent everything of importance that was done prior to Dr. Auer von Welsbach's great adaptation; for the various attempts to improve the Drummond light, the efforts of Bourbouze, Wiesnegg, Popp and Sellon, to render the platinum mantle a success, and such publications as the much quoted patent of Stokes Williams, have no real bearing on the subsequent introduction of the incandescent mantle.

Bunsen's laboratory at Heidelberg, which was the birthplace of the Bunsen burner, also supplied the idea of the mantle in the form which has revolutionised our systems of lighting, as it was here that Dr. Auer pursued those studies and researches on the rare metals and their salts, which afterwards stood him in such good stead.

The most generally credited story of his discovery is, that whilst he was boiling a solution containing salts of some of the rare metals, the liquid boiled over, and evaporated on the fibres at the ragged edge of a piece of asbestos card which served to support the beaker, and round which the flame was lapping. This endowed them with such luminosity as to attract Dr. Auer's attention, and he then devised a method of preparing a mantle of the oxides of these metals that should fit the Bunsen flame, and should be made up of sufficiently attenuated filaments to allow of the flame raising it to a sufficient degree of incandescence.

It is more likely, however, that as the high power of incandescing possessed by the oxides covered in his first patent of 1885 were traditions in the laboratory from the work of Bahr and Bunsen, the application of the principle underlying Talbot's and Frankenstein's experiments to the formation of a practicable mantle from these salts was in reality the first great initial step.

Be this as it may, it is impossible to give Dr. Auer von Welsbach too much credit for having brought into a practical form odds and ends of knowledge which up to this period had been almost useless, and which after another seven years of work and experience have resulted in one of the most remarkable successes of modern times.

In his 1885 patent, Welsbach protected the idea of making a mantle by saturating the cotton fabric and then burning off, using mixtures of the salts which he gives as—

60 per cent. of zirconia or oxide of zirconium.
20 ,, oxide of lanthanum.
20 ,, oxide of yttrium.

The oxide of yttrium may be dispensed with, the composition being then—

50 per cent. of oxide of zirconium.
50 ,, ,, lanthanum.

Instead of using the oxide of yttrium, ytterite earth, and instead of the oxide of lanthanum, cerite earth containing no didymium and but little cerium, may be employed.

The mantles made under this patent served the purpose of accustoming the public to the idea, but commercially were a total failure, as the light they emitted hardly exceeded that which the Clamond basket had given, whilst they were far more fragile.

A number of tests made between 1886 and 1889, showed the light emitted to vary from three to six candles per cubic foot of gas consumed, the higher value being rarely reached; whilst on making mantles with the purer materials obtainable at the present time, according to the prescriptions given in the 1885 patent, the results obtained are :—

Composition of Mantle.		Gas Consumed.	Illuminating Power.	Candles per c. ft.
I.	Per cent.	c. ft.	Candles.	
Zirconia .	60	5·4	12·9	2·4
Lanthana	20			
Yttria .	20			
II.				
Zirconia .	50	5·5	9·4	1·7
Lanthana	50			

This shows that a good deal of the candle power of the earlier mantles was due to impurities present in the salts used, and also to the fact that the prescriptions used were continually being varied in hopes of improving the results, when obtainable, thoria being used to replace the zirconia.

In 1886, Welsbach took out his second patent, which covered the use of thoria, either when used alone or mixed with zirconia, magnesia, yttria, erbia, neodidymia, lanthana, alumina, etc.

It is evident from the text of the foreign patents which correspond with the 1886 patent, that Welsbach had the impression that a pure thoria mantle had a very high power of emitting light, and that it was for this purpose that he patented it; whilst, in point of fact, if the thoria be pure it emits practically no light at all, though later experience showed that it had properties which rendered it the most important of the oxides used in mantle manufacture, as its refractory nature gives a stability to the feeble structure that cannot be obtained by any other known body.

The thoria mantles made under the 1886 patent gave a service of 6 candles per cubic ft. of gas consumed, but when now made with pure thoria, as specified in the patent, they give a duty of less than 1 candle per cubic ft. of gas, whilst the other mixtures specified in the patents give results which hardly come within the range of practical utility.

The use of ceria, together with thoria, is mentioned in some of Welsbach's early foreign patents, but the exact date at which it was first realised that traces of ceria had the marvellous effect on the light emissivity of the thoria mantle that we find in the mantles of to-day, is not very clear. It is evident, however, that the advantage of the presence of small quantities of ceria was beginning to be realised by 1891, when Mr. W. Mackean, the chemist of the English Welsbach Company, read a very interesting paper before the Society of Chemical Industry, and pointed out that the use of ceria is by no means a disadvantage in small quantities, as it adds to the constancy of the illuminating power. He gave a table showing the influence of the presence of ceria, and also the influence upon the light which increasing quantities of ceria have. Thus, for instance, the ordinary percentage of ceria is 0·25, and this gives 25 candles for a consumption of 2·5 cubic ft. of gas, or 10 candles per ft., but an increase in the percentage of ceria to 0·5 reduces this to 18 candles for 2·5 cubic ft. When 1 per cent. of ceria is added, a further reduction to 13·5 candles for the 2·5 cubic ft. is found; but, whilst the candle-power lost 43·2 per cent. in 1000 hours with the 0·25 per cent. of ceria, it only lost 12·6 per cent. in one experiment, and 28 per cent. in another, with 1 per cent. of ceria present originally. He also, in the same paper, gave the composition for a mantle giving a yellowish light—lanthana 40 per cent., thoria 28 per cent., zirconia 30 per cent., and ceria 2 per cent.—showing that at this period the use of small quantities of ceria in mantles containing thoria was by no means unknown.

—	Gas Consumed.	Light Emitted	Candles per c.ft.
I.			
Thoria (3 parts) . Magnesia (2 ,,) .	4·4	9·0	2·0
II.			
Thoria (1 part) . Zirconia (1 ,,) . Yttria (1 ,,) .	4·5	15·0	3·3
III.			
Thoria (30 p.c.) . Zirconia (30 ,,) . Lanthana (40 ,,) .	4·7	12·2	2·5
IV.			
Thoria (2 parts) . Magnesia (1 ,,) . Lanthana (2 ,,) .	4·5	12·2	2·7
V.			
Thoria (3 parts) . Magnesia (1 ,,) . Lanthana (1 ,,) .	4·0	3·6	0·9

About this date mantles on the Continent began to show a marked improvement, and in 1891–1892 it was reported that Welsbach had produced new mantles yielding as much as 16 and 17 candles per cubic ft. of gas consumed, and the same great improvement manifested itself in the English mantles. The cause of the great advance was made clear the following year by Mr. Moeller taking out the patent of 1893, in which he sought protection for thoria in combination with very small traces—not exceeding 1 or 2 per cent.—of the oxides of certain other rare metals, such as uranium, cerium, terbium, neodidymium, samarium, praxeodymium, yttrium, and lanthanum. The mantles of today nearly all consist of 99 per cent. of thoria and 1 per cent. of ceria, as, although several of the oxides mentioned, in minute traces, endow a non-luminous thoria mantle with the power of emitting light, yet ceria so far transcends the others in its capacity of not only exciting luminosity, but of keeping up the illuminating power over a long period, that as far as our present knowledge goes, it is needless to look beyond it.

Many experiments have been made in order to determine the effect of the percentage of ceria when added to thoria on the light emissivity of the mantle, and the results obtained vary in putting the highest light emissivity at from 0·9 to 3 per cent. of ceria, the reason of this discrepancy being due to a number of small causes acting together.

In order to get the maximum result, exact air adjustment is necessary, and traces of impurities must be very carefully eliminated. Under these conditions, the point of maximum emissivity is reached when the mixture is 99 per cent. thoria, and 1 per cent. ceria. At this highest point, however, the mantle is peculiarly sensitive to air adjustment, and if this is not attended to in the most careful way, the results may vary between the limits indicated. Moreover, it is necessary that the mantles should have been most carefully treated, first with dilute alkali, then with dilute acid, and should finally be thoroughly washed with distilled water and dried under conditions which preclude the possibility of their being contaminated with dust.

If these conditions are observed it is found that, starting with a pure thoria mantle giving practically no light, the candle power rapidly rises as traces of ceria are added to it until the maximum is reached, when it again rapidly falls away with further increments of ceria, the colour of the light undergoing at the same time a very marked change, and acquiring a yellowish tint which with increasing quantities becomes gradually of a reddish character.

The narrow limit within which the highest light emissivity exists render a careful proportioning of the liquid for soaking the mantle of the greatest importance.

Experiments have also been made in order to try the effect which additions of various proportions of ceria have upon the life of useful light emission which the mantle possesses. These show that with a Welsbach mantle made under the ordinary conditions of impregnating the cotton fabric with a solution of the nitrates of thorium and cerium, the higher the initial illuminating value, the more marked is the loss in light over a given space of time.

In the ordinary burning of a commercial Welsbach mantle it is generally found that the light increases for a certain period, and that then a steady fall in illuminating power takes place, the initial period of gain in light emissivity being most probably due to the mantle shaping itself to the flame, whilst the gradual fall in power which takes place after that period has been completed is chiefly due to dust particles containing silica which are drawn in over the surface of the mantle by the chimney draught, and which, fusing on the outside of the fine filaments form silicates having a lower power of light emissivity than the original oxides. This point will again be reverted to in the following lecture, where I shall have to show the important bearing which the form of the filaments composing the mantle has upon this power of keeping up its illuminating value.

Since the facts which I have brought before you with regard to the thoria-ceria mantle have been fully ascertained, innumerable attempts have been made to evade the patent under which the Welsbach mantle is manufactured, but so far these attempts have not been of much profit to any but the legal profession and the experts. Indeed it may be stated that the only mantle which in England has had its position placed upon the same legal footing as the Welsbach mantle is the Sunlight mantle, in which advantage was taken of the power which oxides of chromium have of exciting luminosity when superimposed on a structure of alumina.

In some of the mantles which have been proposed, small quantities of acidulous bodies are added, such as silicic acid, or the oxides of arsenic and antimony, with the view of converting a portion of the thoria into silicate, arseniate, etc., but in no case that I have tested does the alteration improve the mantle either in life or light emissivity.

In the "Voelker" mantle a basis of thoria is produced, which is then coated by dipping in a substance termed by the patentee "Voelkerite," a body made by fusing together a number of oxides in the electric furnace; the fused mass so obtained is then dissolved in the strongest nitric acid, and diluted with absolute alcohol to the necessary degree. A very good mantle, having great lasting power, is thus produced. It is claimed that the process of fusing the materials together in the electric furnace alters the composition in some unexplained way, but the true explanation is probably that all water of hydration is eliminated.

The "Daylight" mantle consists of a basis of thoria, or thoria mixed with zirconia, which is then dipped in collodion containing a salt of cerium in solution, and on burning off the collodion the ceria is left in a finely divided condition on the surface of the thoria. There is no doubt that in this way a very high initial illuminating power is obtained, and I have seen mantles made on this principle which, within a few hours of their ignition, have given a total illuminating value of 100 candles with a service of 24 to 25 candles per cubic foot.

The "Crown" mantle, which is very largely adopted in Berlin, is a mantle of this description, produced by making a mantle of pure thoria from a fabric of ramie saturated with the nitrate, and then dipping the thoria basis in a mixture of 99 per cent. thoria and 1 per cent. ceria, the mantle so produced being of very considerable strength, and retaining its power of light emissivity for a much longer period than the ordinary Welsbach mantle.

It will be well now to tabulate the oxides which have been used in the manufacture of incandescent mantles, and see the amount of light emitted by each under the conditions existing in the mantles.

LIGHT EMITTED BY VARIOUS OXIDES.

Oxide.	Pure.	Commercial.
Metals.		
Zirconia	1·5	3·1
Thoria	0·5	6·0
Earth Metals.		
Cerite Earths—		
Ceria	0·4	0·9
Lanthana	—	6·0
Yttrite Earths—		
Yttria	—	5·2
Erbia	0·6	1·7
Common Earths—		
Chromium Oxide	0·4	0·4
Alumina	0·6	0·6
Alkaline Earth Metals.		
Baryta	3·3	3·3
Strontia	5·2	5·5
Magnesia	5·0	5·0

In utilising these oxides for the manufacture of mantles, it is evident that there are many points besides the power of emitting light which must be taken into consideration.

Some salts shrink so much during the conversion by burning into oxides that a mantle of very considerable initial size would have to be taken in order to get a skeleton of oxide of sufficient dimensions to fit the flame; other oxides which promise well as far as their shrinkage during formation goes, are found to slowly volatilise under the influence of the Bunsen flame, so that in the zone of most intense heating the thread of oxide gets thinner and thinner, and gradually disappears; other oxides, again, are brought too near to their point of fusion, and soften to such an extent that the mantle shrinks in where most heated and gets inside the zone of greatest heat, giving rise to a considerable loss of light, whilst other oxides, like yttria, give so distinctly coloured a light as to be objectionable. Careful testing both as regards duration and strength leads one to the conclusion that of the oxides given, thoria, zirconia and alumina alone can be used for forming the structure of the mantle; but alumina has the drawback that the mantle is very hard and not easily shaped in the blow-pipe, shrinks in the zone of greatest heat and slowly volatilises, whilst zirconia mantles are liable to considerable and rapid shrinkage, so that thoria practically stands alone as the ideal basis for a mantle, as it is easily shaped in the blow-pipe flame, gives a comparatively small shrinkage, when the fabric containing the nitrate is being converted into oxide, and when formed the mantle resists the action of temperature for a longer period than any other known oxide.

Perhaps the most important property is the enormous increase which takes place when thorium nitrate is converted into oxide, as, if a comparatively small mass of nitrate be heated on platinum foil, it swells up in much the same way that the sulphocyanide of mercury constituting the old "Pharaoh's serpent" does, and the small bulk of nitrate becomes an enormously larger mass of thorium oxide, so that although in the mantles as now used there is 1 per cent. of ceria by weight, the proportion by volume is less than 0·1 per cent.

Having got the basis of thoria, it is seen that in its pure condition it only emits about half a candle of light per cubic foot of gas consumed, but the difference between the lighting power of the pure thoria and the commercial at once indicates how sensitive it is to the exciting influence of small traces of impurities. When admixed with 1 to 2 per cent. of ceria, it acquires a power of light emissivity combined with duration which is unequalled by any other known mixture of the available oxides.

Many attempts have been made to explain in a satisfactory manner the marvellous power which the minute trace of ceria has of awakening to life the light-giving power of the mantle. In order that the mantle may emit its full measure of luminosity it has to be heated in the extreme fringe of the outer zone of the Bunsen flame, and here it is that the combinations take place between the products of incomplete combustion and the oxygen of the air.

The theory now most generally accepted is that propounded by Dr. Bunte, who ascribes the high illuminating effect produced by the trace of ceria as being due to a catalytic action of the same character as causes a piece of platinum foil, which has been heated in order to cleanse its surface, to become red hot when a current of mixed coal gas and air is allowed to impinge upon it, the action here being due to the power which platinum possesses of compressing both coal-gas and air upon its surface, and rendering them so chemically active that they combine on the surface of the metal, and emit sufficient heat to raise the mass to a bright red.

There are many facts which tend to

support the theory that the light is due to the particles of the oxide of ceria being heated to a higher temperature than that of the flame. My own researches on the cause of the luminosity of flame, point to the splitting up of the molecule of acetylene with the liberation of the endothermic heat contained in it as endowing the carbon particles with a temperature far above that which exists in the flame, so that the temperature of incandescence in the hydro-carbon flame is due to the heat of the combustion, plus the local endothermic heat of the decomposition, and in the same way in the mantle it is probably the heat of the flame which heats the whole of the mantle, plus the locally intensified points of excessively high temperature due to the catalytic action of the ceria upon the mixture of oxygen, carbon monoxide, and hydrogen, that gives the intense power of emissivity that the mantle possesses, the theory being made more probable by the fact that other substances known to have catalytic powers, when used in sufficiently small traces, give similar although not such marked results.

Sunlight Mantles.—Analyses of the "Pink Sunlight Mantles" show them be composed of—

Alumina	86·83
Chromium Oxides .	8·68
Zirconia	4·44
	100·00

The zirconia being added to give greater strength to the mantle.

In these mantles the alumina, if used alone, would volatilise slowly at the heat of the Bunsen flame, so that in the zone of greatest intensity the threads rapidly would become thinner and thinner until finally they would disappear, this point being arrived at before the mantle has been in use 100 hours; the alumina, moreover, is near its fusion point, and is softened and rapidly shrinks. The oxides of chromium also slowly evaporate when continuously heated, so that the materials do not give much promise in making a good mantle, but when mixed together, or when the alumina mantle is sprayed with a dilute chromium solution, a far more stable compound is formed, of a pink colour, and it probably dissociates slowly when heated for a long period, yielding a continuous supply of traces of oxides of chromium, which are the real source of the luminosity, and gradually burn off.

If, instead of an alumina basis, a pure thoria mantle be sprayed with the chromium solution, it becomes endowed with a certain degree of luminosity, but this rapidly falls away, there being nothing to prevent the volatilisation of the chromium oxides.

The property which the chromium has of increasing the illuminating power, and prolonging the life of such basic bodies as it can unite with, is well shown in the case of the Fahnehjelm comb, which was originally made of magnesia rods, and lasted barely 100 hours, so rapidly did the magnesia volatilise; when, however, the idea arose of dipping the magnesia rods into a solution of chromic acid, it was found that not only was the power of emitting light nearly doubled, but that the life of the comb was increased fourfold.

Many attempts have been made to improve upon or alter the composition of the 99 per cent. thoria and 1 per cent. ceria mantle by mixing such bodies as zirconia with the thoria, but it is nearly always found that any attempts in this direction tend to make the mantle far more susceptible to shrinkage, whilst if the foreign body so introduced is present in sufficient quantity to give any practical economy on the thoria saved, the light is at once affected.

Dr. Ernst Hintz, of Wiesbaden, whose researches on the composition of incandescent mantles and the influence of various factors on their light emitting power are, perhaps, the most complete ever made, found that quantities of neo-didymia, lanthana, and yttria up to 2 per cent. have no influence on the light emitted by a mantle, the remainder of which consists of thoria and ceria in the ratio of 99 to 1, that 2 per cent. of zirconia just begins to affect the mantle, and that larger quantities of any of these bodies have a detrimental effect upon the light. His experiments and researches are of especial interest, as they show fairly conclusively the inception of the present mantle from the compositions mentioned in the 1886 or thoria patent.

The two minerals available for the preparation of thorium salts at the time of this patent, and indeed up to about 1892, were thorite and orangite. These are found in Norway, and are crude hydrated silicates of thorium, containing from 50 to 72 per cent. of thoria, together with traces of several other oxides of the rare metals, including ceria. From these the liquid for impregnating the mantles was made without any special precautions being taken to eliminate the traces of the other rare earths, the mantles made from this fluid being looked upon as consisting of pure thoria, whilst Dr. Hintz and others found that by employing the same methods of separation as were used for the manufacture, the composition of the oxides made from the fluids obtained from these minerals was—

	Thorite.	Orangite.
Thoria . . .	96·606	92·416
Ceria . . .	0·994	3·162
Neo-didymia and Lanthana .	1·205	3·227
Yttria . . .	1·195	1·195

compositions which agree very closely with analyses made of mantles sold in 1891–92, and which yielded an illuminating power of the same value as mantles made from liquids of this composition.

Monazite, which is the source from which the thoria now used is obtained, is mainly composed of phosphate of cerium and lanthanum, together with the phosphates of other rare earths, amongst which is thorium in quantities varying from a little over 1 to 16 per cent., and traces of many other bodies. This mineral, which used to be considered extremely rare, has now been found to be very widely distributed, its chief sources being the United States, Brazil, Siberia, Canada, etc., where it is found in the form of sand produced by the disintegration of primitive rocks.

Ceria, being the main constituent of the monazite, and occurring in far larger proportion than the thoria, is separated with a much greater degree of completeness at the present time than was the case with the thoria made from orangite and thorite; indeed, it was only a few observers who, prior to 1890, had stated that thorite and orangite contained ceria.

Small as is the percentage of thoria in monazite, and laborious as is the separation of the thoria from it, the discovery of these large supplies of the mineral has reduced the price of thorium nitrate, according to Dr. Hintz, from £100 per kilo at the end of 1894 to the present price of about 30*s*. per kilo.

Of late years an important variation has been introduced in the manufacture of some mantles, in which, while the mixture of 99 per cent. thoria and 1 per cent. ceria was employed, the principle under which the old Clamond basket was made has been pressed into service. As pointed out in the previous lecture, these baskets were made in the early eighties by weaving together filaments which had been formed by squeezing a paste of magnesia and magnesium acetate through a suitable orifice, and the woven mantle when baked, could be rendered incandescent by means of an ordinary burner owing to the threads being reduced to a sufficient degree of fineness.

On November 4, 1890, Lungren took out a patent for an improvement in the method of manufacturing the mantle, which was a great advance on Clamond's original process. In this latter method it was found that it was a troublesome matter to get a coherent mantle owing to the threads at the points of intersection not welding properly, the first threads laid on the mould drying before the cross threads were put on, so that, when they were pressed together, the dried threads cut through the softer ones and did not properly unite with them. In order to overcome this, Lungren mixed his refractory earths into a paste with some combustible elastic material, and from this squeezed out the threads from which the mantle was woven, after which operation the elastic binding material was burnt out. As examples of suitable materials Lungren instances glue mixed with glycerine, india-rubber dissolved in naphtha, etc., and states that a variety of materials may be used.

Collodion Mantles.—At the present day collodion is rapidly coming to the front as a vehicle for holding the incandescent oxides.

In 1894 De Mare utilised collodion for the manufacture of a mantle, adding the necessary salts to the collodion before squeezing it into thread. Following in his steps Knofler in 1895 and later on Plaissetty took out patents for the manufacture of mantles by a similar process to De Mare's, the difference between the two being that Knofler used ammonium sulphide for the denitration of his fabric, whilst Plaissetty employed calcium sulphide, the objection to which is the trace of lime left in the material.

Another method of the same kind for making artificial silk, which has a considerable reputation, is that known as the Lehner process, which in its broad outlines somewhat resembles the Chardonnet, but differs from it in that the excessively high pressure used in the earlier method is done away with by using a solution of a more liquid character, the thread being hardened by passing through certain organic solutions. It has been found that this form of silk lends itself perhaps better to the carrying of the salts forming the incandescent oxides than the previous solutions, and mantles made by this process, which we will speak of as Lehner mantles, show promise of being a most important development of De Mare's original idea.

Mantles made by such methods as those of De Mare, Knofler, Plaissetty, and Lehner, are clearly developments of the Clamond hood, and not of the Auer mantle. In the Clamond class the filaments are made by squeezing a homogeneous pasty material through small orifices so as to form rods or threads, and when the vehicle holding the salts is burnt off, the oxides are left in a thread of even density.

The Auer class consists of excessively minute filaments, many hundreds of which go to form a thread, whilst each filament when burnt off after impregnation with the illuminating solution leaves a minute rod of the oxides having a dense central portion, which was produced by the salts by capillary attraction being drawn into the small tubes in the centre of the cotton fibre. This dense central portion is surrounded by a more or less spongy coating formed by the salts on the exterior of the fibre being reduced to oxides, and is kept in a broken-up condition by the escape through them of the gases from the burning fabric.

In the Welsbach mantles you have this enormous mass of small filamentary matter twisted in the thread into what, after burning, becomes practically a fluted column of oxides, whilst in the Clamond class of mantle you have each separate filament that forms the thread standing out separately by itself, so that what appears to the eye to be one solid filament, reveals itself under the microscope as a loose bundle of rods, which vary in number according to the make of the mantle, those made by the Lehner process having rather more of these separate filaments than those made by the Plaissetty and Knofler methods.

This alteration in physical structure has a most extraordinary effect upon the light-giving life of the mantle, and also on its strength, as after burning for a few hundred hours, the constant bombardment of the mantle by dust particles drawn up by the rush of air in the chimney causes the formation of silicates on the surface of the mantle owing to silica being present in the dust, and this seems to affect the Welsbach structure far more than it does the Clamond type, with the result that when burnt continuously the Welsbach mantle falls to so low a pitch of light emissivity after 500 to 600 hours as to be a mere shadow of its former self, giving not more than a third of its original light, whilst the Knofler mantle keeps up its light-emitting power to a much greater extent, and the Lehner fabric is the most remarkable of all.

Comb Tassel Mantles.—The history of the incandescent mantle has not been altogether devoid of attempts to introduce forms suitable for flames other than those given by the Bunsen burner with a circular tube. First and foremost amongst these in the inception of incandescence came the Fahnehjelm comb, made of a number of thin magnesia rods, set in a back of fire-clay, supported by an iron frame clamped above a small Bray burner, in which water-gas was consumed. The comb, however, as has been before stated, burnt away in less than 100 hours owing to the volatility of the magnesia, whilst the light which it emitted even in its prime only amounted to 3 or 4 candles per cubic ft., although it was afterwards found that dipping in a solution of chromic acid brought this up to nearly double value, and increased fourfold the life of the burner.

When the idea of making a fabric was firmly established and the mantles began to be a success, De Mare tried to utilise the flat flame as a source of heat in which to excite a fringe of fabric soaked in a mixture of the salts of the rare earths and burnt off so as to give a comb of very fine oxide filaments. The effect produced by this when properly arranged was extremely good. In the burner employed for this purpose he first tried what was practically a flat-flame Bunsen, which gave very good results, and later he employed a burner in which the coal-gas *per se* was forced out into the air in so thin a sheet that the hydrocarbons in it became thoroughly consumed, and a non-luminous flame was produced. It was possible to do this in Paris as the gas supplied was only 14 candles, and the pressure at which it was distributed 4 to 5 in., so that by using a very small Bray nipple a thin non-luminous flame was produced, which, owing to the admixture of air being only just sufficient to give the desired effect, was hotter that the flat Bunsen flame. It was attempted to introduce these De Mare plumes into England, but the rare earths employed were held to be the equivalent of the earths protected in Welsbach's 1885 patent.

Another very effective variety of incandescent is to be found in the De Lery burner and its cluster of baby mantles or tassels. Taking a Bunsen burner with a dome top, in the sides of which holes were pierced at regular intervals, De Lery obtained a circle of small Bunsen jets, each of which raised to incandescence a small tassel of the oxides of thorium and cerium. These tassels were suspended from a twelve armed circular support, and hung in the corresponding number of flames issuing from the top of the burner. The effect given is most excellent, as the spreading of the incandescence over a considerably larger surface prevents the irritation of the eye so prevalent with the ordinary mantle, whilst the diffusion of light obtained in the room is distinctly superior.

A great difference exists between the measurement of illuminating power as carried out on the photometer, and the illuminating effect which one obtains from illuminants in practice. The De Lery tassel burner is as good an example of this phenomenon as can be found, for although it gives less light than the ordinary incandescent mantle, when tested at the horizontal in the photometer, its illuminating effect is far superior, and the light, being mostly cast in a downward direction, illuminates the surface below the burner, whilst with the ordinary mantle the bulk of the illumination is thrown from the horizontal upwards, owing to the form of mantle being a cone. These burners with their tassels have proved very successful in America, and I am informed that they will shortly be introduced into this country, when their novelty of appearance and excellent effect will undoubtedly go a long way towards making them a success.

Attempts have also been made to strengthen and increase the amount of light obtainable from the ordinary shape of mantle, a noticeable endeavour in this direction having been made by Plaissetty, who, noticing the great intensity of heat produced over the small area immediately above the burner top, and the tendency which mantles had to shrink at this spot, attempted to both strengthen the mantle and increase its light emissivity by braiding the mantle with clocks or seams of the same incandescent material as that of which the mantle itself was composed. The result, however, did not give promise of any very great increase in illuminating power, and the idea has been, I believe, abandoned. Plaissetty also made mantles consisting of plaited bands of ropes, each perfectly distinct from the other, which were hung from a central support around the mantle head, and which could be burnt off by the consumer, as no shaping was required.

* * *

GAUGING AND ULLAGE OF CASKS.

IN taking the dimensions of a cask, it must be carefully observed : (1) That the bung-hole be in the middle of the cask ; (2) That the bung-stave, and the stave opposite to the bung-hole, are both regular and even within ; (3) That the heads of the cask are equal, and truly circular ; if so, the distance between the inside of the chime to the outside of the opposite stave will be the head diameter within the cask, very near.

RULE.—Take, in inches, the *inside* diameters of a cask at the head and the bung, and also the length ; subtract the head diameter from the bung-diameter, and note the difference.

If the measure of the cask is taken outside, with callipers, from head to head, then a deduction must be made of from 1 to 2 in. for the thickness of the heads, according to the size of the cask.

1. *If the staves of the cask, between the bung and the head, are considerably curved* (the shape of a pipe), multiply the difference between the bung and head by ·7.

2. *If the staves be of a medium curve* (the shape of a molasses hogshead), multiply the difference by ·65.

3. *If the staves curve very little* (less than a molasses hogshead), multiply the difference by ·6.

4. *If the staves are nearly straight* (almost a cylinder), multiply the difference by ·55.

5. Add the product, in each case, to the head-diameter ; the sum will be a mean diameter, and thus the cask is reduced to a cylinder.

6. Multiply the *mean* diameter by itself, and, then by the length and multiply, if for wine gallons, by ·0034. The difference of dividing by 294 (the usual method), and multiplying by ·0034 (the most expeditious method), is less than 500ths of a gallon in 100 gallons.

Example.—Supposing the head-diameter of a cask to be 24 in. the bung-diameter 32 in., and the length of cask 40 in., what is the contents in wine gallons ?

First Variety.

```
Bung-diameter   .  32  Brought up  876·16
Head-diameter.  .  24  Length.  .      40
                   ——            ————————
Difference . . .    8            35046·40
Multiplier . . .   ·7               ·0034
                   ——            ————————
                  5·6            14018560
Head-diameter.   24             10513920
                 ————          ——————————
                 29·6          119·157760
Multiply by  .   29·6
                —— ——
[Carry up] Square, 876·16  Ans. 119 gal. 1 pint.
```

To obtain the contents of a similar cask in ale gallons, multiply 35046·40 by ·002785, and we get 97·6042 (or 97 gal. 5 pt.).

Gauging of Casks in Imperial (British) Gallons, and also in United States Gallons.—Having ascertained the *variety* of the cask, and its *interior* dimensions, the following table will facilitate the calculation of its capacity.

Divide the head by the bung diameter, and opposite the quotient in the column H, and under its proper variety, is the tabular number for unity. Multiply the tabular number by the square of the bung-diameter, of the given cask, and by its length, the product equals its capacity in imperial gallons.

Required the number of gallons in a cask (1*st variety*) 24 in. head-diam., 32 bung-diam., and 40 in. in length ?

```
32)24·0(·75, see Table for tabular No.
        ·0024195 tabular No. for unity.
32×32 is    1024 square of bung diam.
           96780
          48390
         24195
       —————————
       2·4775680
              40 inches long.
      ——————————
      99·1027200 Imperial gallons.
             1·2
      ——————————
      1982054400
      991027200
    ————————————
    118·92326400 United States gallons.
```

Note.—Multiplying Imperial gallons by one and two-tenths (1·2) will convert them into U.S. gallons; and U.S. gallons multiplied by ·833 equal Imperial gallons.

TABLE OF THE CAPACITIES OF CASKS, WHOSE BUNG DIAMETERS AND LENGTHS ARE 1 OR UNITY.

H.	1st Var.	2nd Var.	3rd Var.	4th Var.	H.	1st Var.	2nd Va.	3rd Var.	4th Var.
·50	·0021244	·0020300	·0017704	·0016523	·76	·0024337	·0024120	·0022343	·0022071
·51	·0021340	·0020433	·0017847	·0016713	·77	·0024482	·0024282	·0022560	·0022310
·52	·0021437	·0020567	·0017993	·0016905	·78	·0024628	·0024445	·0022780	·0022551
·53	·0021536	·0020702	·0018141	·0017098	·79	·0024777	·0024610	·0023002	·0022794
·54	·0021637	·0020838	·0018293	·0017294	·80	·0024927	·0024776	·0023227	·0023038
·55	·0021740	·0020975	·0018447	·0017491	·81	·0025079	·0024942	·0023455	·0023285
·56	·0021845	·0021114	·0018604	·0017690	·82	·0025233	·0025110	·0023686	·0023533
·57	·0021951	·0021253	·0018764	·0017891	·83	·0025388	·0025279	·0023920	·0023783
·58	·0022060	·0021394	·0018927	·0018094	·84	·0025546	·0025449	·0024156	·0024035
·59	·0022170	·0021536	·0019093	·0018299	·85	·0025706	·0025621	·0024396	·0024289
·60	·0022283	·0021679	·0019261	·0018506	·86	·0025867	·0025793	·0024638	·0024545
·61	·0022397	·0021823	·0019433	·0018715	·87	·0026030	·0025967	·0024883	·0024803
·62	·0022513	·0021968	·0019607	·0018925	·88	·0026196	·0026141	·0025131	·0025063
·63	·0022631	·0022114	·0019784	·0019131	·89	·0026363	·0026317	·0025381	·0025324
·64	·0022751	·0022262	·0019964	·0019352	·90	·0026532	·0026494	·0025635	·0025588
·65	·0022873	·0022410	·0020147	·0019568	·91	·0026703	·0026672	·0025891	·0025853
·66	·0022997	·0022560	·0020332	·0019786	·92	·0026875	·0026851	·0026150	·0026120
·67	·0023122	·0022711	·0020521	·0020006	·93	·0027050	·0027032	·0026412	·0026389
·68	·0023250	·0022863	·0020712	·0020228	·94	·0027227	·0027213	·0026677	·0026660
·69	·0023379	·0023016	·0020906	·0020452	·95	·0027405	·0027396	·0026945	·0026933
·70	·0023510	·0023170	·0021103	·0020678	·96	·0027585	·0027579	·0027215	·0027208
·71	·0023643	·0023326	·0021302	·0020905	·97	·0027768	·0027764	·0027489	·0027484
·72	·0023778	·0023482	·0021505	·0021135	·98	·0027952	·0027950	·0027765	·0027763
·73	·0023915	·0023640	·0021710	·0021366	·99	·0028138	·0028137	·0028044	·0028043
·74	·0024054	·0023799	·0021918	·0021599	1·00	·0028326	·0028326	·0028326	·0028326
·75	·0024195	·0023959	·0022129	·0021834					

To Ullage, or find the contents in Gallons of a Cask partly filled.—To find the contents of the occupied part of a lying cask in gallons.

RULE.—Divide the depth of the liquid, or wet inches, by the bung-diameter, and if the quotient is under ·5, deduct from the quotient *one-fourth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons in the cask. But if the quotient exceeds ·5, add *one-fourth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the number of gallons.

Example 1. — Suppose the bung-diameter of a cask, on its bilge, is 32 in. and the whole contents of the cask 118·80 U.S. standard gallons; required the ullage of 15 wet inches.

32) 15·00 (·46875
·5 − ·46875 = ·03125 ÷ 4 = ·0078125
·46875 − ·0078125 = ·4609375 ×
118·80 = 54·759375 U.S. gallons.

Example 2.—Required the ullage of 17 wet inches in a cask of the above capacity.

32)17·00(·53125 − ·5 = ·03125 ÷ 4 = ·0078125 + ·53125 = ·5390625 × 118·80 = 64·040625 U.S. gallons.

PROOF. — 64·040625 + 54·759375 = 118·80 *gallons.*

To find the ullage of a filled part of a standing cask, in gallons.

RULE. — Divide the depth of the liquid, or wet inches, by the length of the cask; then, if the quotient is less than ·5, deduct from the quotient *one-tenth* of what it is less than ·5, and multiply the remainder by the whole capacity of the cask; this product will be the number of gallons. But if the quotient exceeds ·5, add *one-tenth* of that excess to the quotient, and multiply the sum by the whole capacity of the cask; this product will be the ullage, or contents in U.S. standard gallons.

Example.—Suppose a cask 40 in. in length, and the capacity 118·80 gallons, as above: required the ullage of 21 wet inches.

40)21·000(·525 − ·5 = ·025 ÷ 10 = ·0025 + ·525 = ·5275 × 118·80 = 62·667 U.S. gallons.

NOTE.—Formerly the British wine and ale gallon measures were similar to those now used in the United States and British Colonies.

The following Tables exhibit the comparative value between the United States and the present British measures.

U.S. measure for wine, spirits, etc.		British (Im.) measure gal.	qt.	pint	gill
42 gal. = 1 tierce	=	34	3	1	3
63 ,, = 1 hogsh.	=	52	1	1	3
126 ,, = 1 pipe	=	104	3	1	3
252 ,, = 1 tun	=	209	3	1	2

U.S. measure for ale and beer.		British (Im.) measure. gal.	qt.	pint	gill
9 gal. = 1 firkin	=	9	0	1	1
36 ,, = 1 barrel	=	36	2	0	3
54 ,, = 1 hogsh.	=	54	3	0	1
108 ,, = 1 butt	=	109	3	1	3

To convert imperial gallons into United States wine gallons, multiply the imperial by 1·2. To convert U.S. gallons into imperial, multiply the U.S. wine gallons by ·833.

51 U.S. ale gallons equal 60 imperial gallons, therefore to convert one into other add or deduct $\frac{1}{60}$th. (Van Cleve.)

The best method is to take the length, with long callipers, which allows 1 in. for end wood, and circumferences at bung and end (at limit of internal capacity), after marking off depth of chime and end wood, and also circumference of "middle diameter"—viz., at quarter of total length from each end—measure both and take the mean, not halfway between bung and chime, which differs. Having found the three circumferences, set 7 on B to 22 on A on double-slide rule (which can be had from any dealer in hydrometers) and under circumference on A find diameters on B, or multiply circumference by 7 and divide by 22. Having found the three diameters, set length inches on C to 46 (being the multiplier of frustum) on D, and over once the bung diameter, once the end, and twice the "middle" diameters on D will be found the gallons on C, the sum of which is the total contents. This is a sure method. ('English Mechanic.')

To find the amount of water in a horizontal cylindrical boiler, partially full; or to check the quantity of water evaporated from a steam boiler of this shape.—To find the quantity of water in a horizontal cylindrical vessel, the first thing to do is to find the area of that part of an end plate which has water against it, and which must form a segment of a circle. Having found this area in square feet it now remains to multiply by the length of the boiler in feet, which will give the number of cubic feet of water it contains, and this divided by 6¼ (6·23 actually) will give the amount in gallons.

A rough and ready method of finding the area of a segment of a circle, such as Fig. 211, is to first find the full area of the circle (which is a simple calculation, viz. multiply the radius by the radius, and multiply this by 3·1416; thus for a circle of 4 ft. diameter, 2 × 2 × 3·1416 = 12·5664 ft., or say 12½ sq. ft.). Having found the area of the full circle divide this by two and this will give the area of the lower half of the circle below the centre line, and there then remains but the upper irregular part to be dealt with. To measure this it is calculated as a rectangle as follows. Measure the length of the chord and the length of the centre line (diameter) and then multiply the mean of these by the height from the centre line to the chord. This will give the approximate area, not exact, but approaching exactness and rather less than the true area.

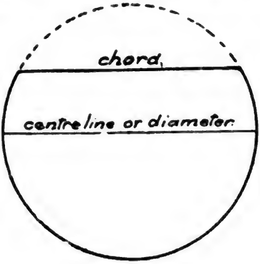

FIG. 211.

The correct mathematical formula for finding the area of a segment of a circle is to first find one-fourth the square of the chord, and add to this two-fifths of the square of the height of the segment. Find the square-root of the preceding sum, and then multiply by four-thirds of the height of the segment

GILDING.

(*See also* ELECTRO-PLATING.)

WOOD, leather, paper, and similar substances, and in some instances, metals, are gilded by covering with leaf gold affixed by an adhesive material. This material is usually one of the different kinds of gold size.

Materials. *Gold Size.*—Yellow ochre, 1 part; copal varnish, 2; linseed-oil, 3; turpentine, 4; boiled oil, 5. Mix. The ochre must be reduced to the finest powder, and ground with a little of the oil before mixing.

Gold Leaf.—To produce this is the business of the gold-beater. The process of gold-beating is exceedingly interesting in its various details, and is one which requires the exercise of much judgment, physical force and mechanical skill. The gold must first be properly refined. The process is as follows: The coin is first reduced in thickness by being rolled through what is known as a "mill," a machine consisting of iron rollers operated by steam power. After being rolled, it is annealed by being subjected to intense heat which softens the metal.

It is next cut up and placed in jars containing nitro-muriatic acid, which dissolves the gold, and reduces it to a mass resembling Indian pudding, both in colour and form. This solution is next placed in a jar with copperas, which separates the gold from the other components of the mass, in the form of grains.

The next process is to properly alloy the now pure gold, which, being mixed with a small quantity of borax, is placed into an earthen pot called a crucible (coated beforehand with a clay to keep it from cracking), and then placed in a furnace, which is raised to a white heat.

The gold, when melted, is poured into an iron mould made warm and greased inside, and when cold, forms an "ingot," which measures 10 in. in length by 1 in. in breadth and thickness. When cooled, it is taken out in the shape of bars. These bars are then rolled into what is called a "ribbon," usually measuring about 80 yds in length, and the thickness of ordinary paper, and retaining their original width. These ribbons are then cut into pieces 1¼ in. square, and placed in what is called a "cutch," which consists of a pack of French paper leaves resembling parchment, each leaf 3 in. square, and the pack measuring from ¾ in. in thickness. They are then beaten for ½ hour upon a granite block, with hammers weighing from 12 lb. to 15 lb., after which they are taken out and placed in another pack of leaves called a "shodder." These leaves are 4½ in. square, and the gold in the shodder is beaten for 4 hours with hammers weighing about 9 lb.

After being beaten in this manner, the gold leaves are taken out of the shodders and placed in what are called "moulds." These moulds consist of packs of leaves similar to other packs, and made of the stomach of an ox. After being made ready in the moulds, the gold is beaten for 4 hours more with hammers weighing 6 lb. or 7 lb. each.

It will be noticed that the thinner the leaf becomes, the lighter are the hammers used, and it is also necessary in beating the gold, especially in striking the mould, that the blow should be given with the full flat of the hammer, and directly in the centre of the mould. Should the beater strike with the edge of the hammer, there is every chance that the leaf will be broken and the pack spoiled. The leaf, after being taken out of the mould, is cut into squares of 3⅜ in. on a cushion of leather, lifted carefully by means of a sort of tongs made of wood and placed in the book. This requires great dexterity, for the leaves are so thin that they would crumple up if not carefully managed.

When they are lifted by the tongs and placed over the leaf of the book, a slight puff of the breath is directed on them which causes them to lie evenly.

They are now between 600 and 700 times thinner than before the beating commenced, and it would take about 280,000 of these leaves to make the thickness of 1 in. The leaves are from 3 in. to 3½ in. square, and are packed in books of common paper having the surface of the leaves rubbed with red chalk, to prevent them from adhering to the gold.

Each book consists of 25 leaves, and there are 20 books in what is known as a pack.

The different colours of the gold leaf are produced by a small alloy of copper or silver, the former giving a deeper and the latter a paler tinge to the pure gold. Gold foil is made in a similar manner to gold leaf, except that the sheets are thick and annealed separately, while the chief distinction is that it has, if a genuine article, no alloy whatever. The article known as German gilt is not made from gold at all. ('Plumber and Decorator.')

Shell Gold, to make.—Take a quantity of leaf gold, mix it with a small portion of honey to a fine paste, add a little gum arabic and sugar candy, with a little water, and mix all well together. Put it in a shell for use.

Test for Gold Leaf:—Apply a drop of nitric acid to the leaf; if it is pure gold, it will remain its proper colour, while if it is not genuine, it will turn black at the spot touched by the acid.

Bronzing Gold-Size is japanners' gold size kept till very bright and tough from age, and then heated up and mixed with 1 gal. very old carriage varnish to 9 gal. gold size. This is used for laying on bronze and also gold, by writers, grainers, japanners, and gilders. The greater the proportion of carriage varnish, the slower it will dry. Some paper-stainers like it to dry quicker than others, and writers and grainers like it to dry quicker than gilders and japanners. (For JAPANNER'S GOLD SIZE, *see* PAINTS, VARNISHES AND JAPANS.)

Fat-oil Gold-Size. is made by grinding good Oxford ochre very fine in old fat linseed-oil; when ground as stiff as possible, it ought to be kept for several years before it is used; the longer it is kept the better it becomes, as it acquires a rich mellow fatness. When this size is to be applied to work, take as much as is necessary, and mix it up with a little good fat boiled oil to a proper consistence, neither too stiff nor too fluid; then apply the size to the ground, laying it very regularly and rather fully, yet not so as to run or fall into wrinkles. Gilding with oil size is suitable for large picture or looking-glass frames, figured or lettered sign-boards, clock faces and various articles exposed to the weather, where a great breadth of gilt surface is required, as it possesses more durability and boldness than any other kind of gilding, particularly when the gilding is varnished before it becomes foul. When it is necessary to revarnish old gilding in oil, such work ought always to be well cleaned from dust, grease, or any incrustation which covers the surface, otherwise the varnish will not dry off hard, but will remain cloudy and tacky, so as readily to retain dust and flies.

Flock Gold-Size.—Put 12 gal. linseed-oil into the iron set-pot; as soon as it has boiled 2 hours, gradually introduce 12 lb. litharge. Continue the boiling very moderately for 6 hours; let it remain until next morning, then bring it to a simmer, and run 10 lb. gum anime and 2 gal. oil. When these two runs of gum are poured into the iron pot, put in 7 lb. Burgundy pitch; continue the boiling and keep ladling it down, as directed for the best gold size, boil it moderately strong, but not over-strong, and when right, mix it with 30 gal. turpentine, or more if required; this should be left a little thicker and stronger than japanners' gold size, as it is used for paper-stainers to lay their flock on, and ought to dry slowly in 1 hour.

Gold Powder for Gilding.—Gold powder may be prepared in three ways. (*a*) Put into an earthen mortar some gold leaf, with a little honey, or thick gum-water, and grind the mixture till the gold leaf is reduced to extremely minute particles. When this is done, a little warm water will wash out the honey or gum, leaving the gold behind in a powdered state.

(*b*) Dissolve the pure gold, or the leaf, in nitro-muriatic acid, and then precipitate it by a piece of copper, or by a solution of iron sulphate. The precipitate, if by copper, must be digested in distilled vinegar, and then washed, by pouring water over it repeatedly, and dried. This precipitate will be in the form of very fine powder; it works better and is more easily burnished than gold leaf ground with honey as above.

(*c*) The best method of preparing gold powder is by heating a prepared amalgam of gold, in an open clean crucible, and continuing the strong heat, until the whole of the mercury is evaporated; at the same time constantly stirring the amalgam with a glass rod. When the mercury has completely left the gold, the remaining powder is ground in a Wedgwood mortar with a little water, and afterwards dried. It is then fit for use. Although the last mode of operating has been here given, the operator cannot be too much reminded of the danger attending the sublimation of mercury. In the small way here described, it is impossible to operate without danger; it is, therefore, better to prepare it according to the former directions than to risk the health by the latter.

Tools.—The tools required are not numerous. The first is the gilder's cushion or pad. This consists of a strip of flat wood about 8 in. by 5 in. covered first with three thicknesses of fine flannel stretched on, these being covered with a thickness of soft chamois or wash leather, this being secured by tacks round the edge of the board. A loop is provided beneath, for the thumb, and a piece of parchment is tacked half way round, forming a wall or wind-guard 3 in. high, as Fig. 212. The chief use of this cushion or pad is to cut, or otherwise prepare, the gold leaf on.

Another essential tool is the "tip," as in Fig. 213, this being a broad, very thin brush, made by gluing camel, or more usually, squirrel hair between two pieces of thin card.

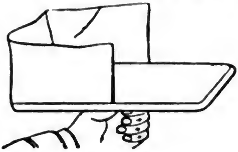

FIG. 212.

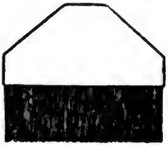

FIG 213.

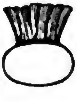

FIG. 214.

A "bob," as Fig. 214, is also necessary, this being a round pad of soft chamois or wash leather, stuffed with cotton wool. Its use is to press the gold leaf down as required.

In addition to these, paint brushes of suitable sizes and shapes are requisite, for applying the gold size, etc., and a moderately sharp and smooth edged knife is required for cutting the leaves as they lie on the pad. The knife should be sharpened on a fine oil stone, as anything like a coarse or "saw" edge is not suitable for cutting gold leaf. The knife has a long flexible blade, which should not be too sharp, set in a light handle like a palette knife. It must be always kept clean and bright. In cutting, the edge of the knife is brought down perpendicularly on to the leaf, and then a slight sawing motion given.

Gold leaf is sold in books of 25 leaves, each about 3 in. square. It is reckoned by the hundred, that is, the contents of four books, and gilders calculate a work to require so many hundreds, not so many books. There are 13 varieties of tint, ranging from a deep orange-red down to a white approximating silver. The gold from which gold leaf is made must be very pure; it is hammered out, after it has been rolled as thin as paper, by being put between the leaves of a book of parchment and extremely thin skins, called gold-beaters' skin; the book is then laid upon a block of marble, and beaten with a heavy hammer. When the leaves of gold are extended to the full size of the book, they are divided, and each portion is placed between the leaves of another book, which is hammered as before. This process is continued till the requisite thinness is acquired. Pale leaf gold has a greenish-yellow colour, and is an alloy of gold with silver. Dutch gold is copper leaf coloured yellow by the fumes of zinc. It is much cheaper than true gold leaf, and is very useful where large quantities of gilding are wanted in places where it can be defended from the weather, by being covered with varnish; it changes colour if exposed to moisture. Silver leaf is prepared in the same manner as that of gold, but is liable to tarnish, except it is well protected by varnish. If covered with a transparent yellow varnish, it has much the appearance of gold.

Processes. *Methods of Gilding.* It may be said that there are but two methods of gilding—that for outdoor work to stand the weather, or that which will wash, and is called oil gilding; this is performed by means of oil or varnish. The other is called water or burnished gilding; it is the most beautiful, and best adapted for fine work, such as frames, articles of furniture, etc., or as applied for the internal decoration of rooms.

How to cut gold leaf, when required in small pieces or narrow strips.—An American author states that if gilders try this method they will find that they can lay twice the amount of leaf in a given time, with the least waste of leaf. Procure a board 2 ft. in length and 8 in. wide. Lay the book of leaf on this board, and with a knife or pair of shears cut the back of the leaves off where they are bound together. Take a small piece of unbleached muslin, wet it with clean turpentine, and with this rub over the top layer of paper. Lift the paper and place on your board so the edge of the paper will extend half an inch or so over the edge of the board so you can pick it up with ease. Care should be taken not to get the cloth too wet or the turpentine will go through the first layer of paper and leaf to the second and stick the two together. Proceed in this way until about half of the book is lifted, if you need that much. It is best not to lift too much at a time until you get it cut the size wanted, as it will handle and cut much nicer if done while the paper is damp.

The above process is intended for large strips only. For ¼ in. strips and under, in place of wetting with turpentine, lift the first layer of paper and give it a few rubs on your trousers' leg to get the chalk off, and then a few rubs on your hair. Then place back on the leaf, and press evenly and hard with the edge of your hands. Take care to keep the paper from moving on the leaf, as it will tear it if moved the least bit.

One leaf can be cut in pieces small enough to lay 8 or 10 ft. of stripe, and, with a little practice, it can be done very speedily too. In cutting, hold the paper so that the pieces fall on the board with their ends extending over the edge ½ in., so you can pick them up with the thumb and forefinger. Never attempt to cut the leaf with new or newly-ground shears, but get the ones with which your wife allows the children to use, these will be just right.

In using turpentine, do not lift more than will do for the job in hand, as it will dry up and come off and be wasted, and stick to the paper so you cannot get it off. In using the outside leaf or cover put it on while quite wet or the leaf will not come off. The finish on the paper will stick the leaf and paper together if allowed to dry.

Dissolving Gold from Gilt Articles. (*a*) Iron and steel articles are ungilt, without any injury to themselves, by dipping them into a bath of 10 parts potassium cyanide and 100 of water, and connecting them with the positive pole of a battery. A wire or foil of platinum is fixed to the negative pole. This is inverting the position of the poles; and in this case the gold applied upon the iron or steel is dissolved in the solution of cyanide, and partly deposited upon the platinum anode, from which it is removed in a regular gold bath. When there is only a film of gold upon iron or steel, it may be removed by the cyanide alone, without the aid of electricity, but this method is slow. Silver, copper, and their alloys may also be ungilt by this process; but the cyanide dissolves, at the same time, the gold, and part of the other metals; it is therefore preferable to operate as follows:—

(*b*) For ungilding silver, it is heated to a cherry-red heat, and immediately thrown into a pickle of more or less diluted sulphuric acid. The gold scales off, and falls to the bottom in the shape of spangles. The operation is repeated until gold no longer appears upon the surface of the silver, which is then white and frosty. This process is not adapted to light and hollow articles, for which the preceding process is better.

(*c*) For copper and its alloys, in small articles, such as false jewellery thinly gilt, either by battery or by dipping, use the following bath: Sulphuric acid, 10 parts; nitric acid, 1; hydrochloric acid, 2. The large quantity of sulphuric acid allows of the solution of gold, whilst it does not sensibly attack copper or its alloys. The sulphuric acid is put alone into a stoneware jar, and the mixture of hydrochloric and nitric acids, kept in a stoppered bottle, is gradually added to it as the operation proceeds. The same sulphuric acid may last a long time, if it is kept well covered, and its dissolving action promoted by successive additions of nitric and hydrochloric acids. The articles should be often withdrawn to watch the operation, which is terminated when no gold is seen, and when the copper has acquired a uniform blackish-grey coat; or by plunging the objects into the compound acids, they will be perfectly cleansed when the gold has all dissolved.

Saltpetre and common salt may be substituted for nitric acid and hydrochloric acid; the salts must be finely powdered and stirred with a glass rod.

(*d*) For large objects, such as clocks or chandeliers, concentrated sulphuric acid, 66° B., is put into a glass or stoneware vessel supporting two brass rods. One of these rods is connected by a conducting wire with the last carbon of a battery of 2 or 3 Bunsen's inverted elements, and supports the objects to be ungilt, which are entirely covered by the sulphuric acid. The other rod supports a copper plate facing the object, and is connected with the last zinc of the battery. The electric fluid traverses the sulphuric acid, and carries the gold from the positive to the negative pole; as the copper plate is not prepared for retaining the gold, it falls to the bottom of the bath in a black powder, which is easily recovered. So long as the sulphuric acid is concentrated, and even under the action of the galvanic current, it does not sensibly corrode the copper; but as it rapidly absorbs the dampness of the atmosphere, the vessel in which it is contained should be kept perfectly closed, when the ungilding process is not in active operation; and the pieces for ungilding should be put in perfectly dry. If it is intended to sacrifice the gilt articles of copper or silver, let them remain in pure nitric acid, which dissolves all the metals except gold, which either floats at the surface of the liquid as a metallic foil, or falls to the bottom as a blackish powder. If the liquor is diluted with distilled water, and filtered, all the gold will remain on the filter, and the solution will contain the other metals.

(*e*) Apply a solution of borax, in water, to the gilt surface, with a fine brush, and sprinkle over it some fine powdered sulphur. Make the piece red hot and quench it in water. The gold may be easily taken off with a scratch-brush, and recovered by testing it with lead.

(*f*) Gold is taken from the surface of silver by spreading over it a paste, made of powdered sal-ammoniac, with aquafortis, and heating it till the matter smokes, and is nearly dry, when the gold may be separated by rubbing it with a scratch-brush.

Cards.—For gilding on cards, the surface must first be rendered non-absorbent by the application of a water size, made from isinglass, gum arabic, or parchment shreds boiled down. The number of coats of size needed will depend on the nature of the card; then oil sizing and gilding follow in due course. An exception to this rule obtains with photographs, in which the albumenising serves as a substitute.

Fascia Lettering, *see* **Signs.**

Glass. *With Gold Leaf.*—(*a*) The operation is performed on the back of the sheet of glass, and this must be borne in mind with reference to the reversed position of the pattern. The surface to be gilt is thoroughly freed from adhering grease, etc., by rubbing with whiting, and the latter is removed by the aid of a silk cloth. Adhesion of the leaf is secured by simply moistening the surface of the glass with the tongue or the breath. When it has become attached and has dried, it is breathed on again, pressed all over with a pad of cotton wool, then warmed by the fire, and finally rubbed with dry clean cotton wool to bring up a polish. Next, on the gilded ground, is marked the pattern which is to be exhibited, and such portion of the leaf is fixed by a coat of Brunswick black or of japanners' gold size containing a pigment such as yellow ochre, which is allowed to dry quite hard before proceeding to rub off the leaf from the portions which are not to be gilt. This rubbing off is done with pieces of wet cotton wool, the hand being meanwhile held off the work by a strip of wood supported across it at a suitable elevation. If the pattern is to be made up of different kinds of leaf (deep and pale golds and silver), each kind is applied in turn, in same manner, all over the unoccupied space, and rubbed out where not wanted. The background is finished by a coat of paint or bronze powder, the latter being rubbed with a "bob" upon a layer of varnish. The preliminary fixing of the leaf may be done with a water size, such as already described, if desired; this takes longer to dry, and, if allowed to get too dry, holds so firmly that it is difficult to remove the superfluous leaf.

(*b*) Drinking and other glasses are sometimes gilt on their edges. This is done either by an adhesive varnish or by heat. The varnish is prepared by dissolving in boiled linseed-oil an equal weight either of copal or amber. This is diluted by a proper quantity of oil of turpentine, so as to be applied as thin as possible to the parts of the glass intended to be gilt. When this is done, which will be in about 24 hours, the glass is to be placed in a stove, till it is so warm as almost to burn the fingers when handled. At this temperature the varnish will become adhesive, and a piece of leaf gold, applied in the usual way, will immediately stick. Sweep off the superfluous portions of the leaf, and when quite cold it may be burnished, taking care to interpose a piece of very thin India paper between the gold and the burnisher. If the varnish is very good, this is the best method of gilding glass, as the gold is thus fixed on more evenly than in any other way.

(*c*) It often happens when the varnish is but indifferent, that by repeated washing the gold wears off; on this account the practice of burning it in is sometimes had recourse to. For this purpose, some gold powder is ground with borax, and in this state applied to the clean surface of the glass by a camel-hair pencil; when quite dry, the glass is put into a stove heated to about the temperature of an annealing oven: the gum burns off, and the borax, by vitrifying, cements the gold with great firmness to the glass; after which it may be burnished. The gilding upon porcelain is in like manner fixed by heat and the use of borax.

(*d*) The glass should be thoroughly cleaned and polished. A size must be prepared as follows: Isinglass 1 oz., dissolve in just sufficient water to cover it; when dissolved, add 1 pint rectified spirits of wine, then increase the quantity to 1 qt. with water; keep tightly corked. Or, take best rum ½ pint, isinglass ¼ oz. Dissolve the isinglass in the rum at a low temperature, then add ½ pint distilled water and filter through a piece of old linen. Place the glass flat on a perfectly level table, then with a clean brush flood the glass with the size to the depth of $\frac{1}{16}$ in., raise the gold leaf with a tip and lay it flat on the size; it will almost instantly adhere to the glass; in 5 minutes afterwards place the glass endways at a slight angle against a wall, that the surplus size may drain off. Allow the glass to remain in that position for 24 hours; by that time it will be perfectly dry. Draw the pattern or letter on a piece of paper, and with a thick needle pierce holes on the lines at the distance of $\frac{1}{16}$ in. apart; place the pierced paper on gold surface, then dust some powdered whiting well on the paper that it may penetrate the holes; remove the paper carefully, and there will remain a correct copy of the design on the gold. Now fill up the outlines of the design with oil gold size in which has been ground some orange chrome, thin it with a little boiled oil and turpentine. When thoroughly dry, wash off the surrounding gold with water and a piece of cotton wool. Back the glass with any suitable colour.

(*e*) *Burnished.*—The gold used is the ordinary gold leaf. Procure some fine isinglass, and place about as much in a tea-cup as will cover a sixpenny piece, and then pour on it about half a cupful of boiling water, which will dissolve the isinglass. Before the water is cold add about as much spirits of wine as there is water in the cup; then strain the whole through a clean silk handkerchief, and the mordant is ready for use. The addition of the spirits of wine is most material, as without it the gilding cannot be satisfactorily accomplished.

Whatever may be the design or lettering, it must first be set out on a sheet of white paper, and painted with Brunswick black, so that it can be seen on the reverse side. This paper with the writing reversed, should be fixed at the edges or corners to the glass, the writing, of course, appearing backwards. The glass having been thoroughly cleansed and rubbed with a silk handkerchief, the gilding may be commenced, the gold leaf being laid on the reverse side to that to which the paper is attached. It is usual to place the glass in a slanting position on an easel, the lines of lettering not being horizontal, or reading from left to right, but perpendicular, reading from top to bottom. The mordant is put on with a large soft camel-hair pencil, and the gold leaf is lifted from the cushion and placed on the mordant with a tip, after having been cut to the required dimensions.

If the line of writing is less than 3 in. high, it is advisable to gild the whole line, without paying any regard to the shapes of the letters, so that when the line is finished it will be a solid piece of gilding about the same height and length as the letters. The first piece of gold leaf should be placed at the beginning of the line, which is the top of the glass, and each succeeding piece below it, the different pieces just overlapping each other. It is necessary to be particular in this, for if the pieces of gold do not meet, the interstices will probably show when the work is completed, and will prevent the uniformity of burnish. For letters larger than 3 in. high, the gilding may be made to cover each letter, leaving the spaces between untouched. As soon as this part of the gilding has been completed, it should be left to dry in a warm room, or placed before the fire, in which case it will be dry in a few minutes.

When the gilding is perfectly dry and bright, it should be rubbed over very gently with a piece of cotton-wool. This will heighten the burnish of the gold, and remove the loose pieces which do not adhere to the glass. After the gilding has been treated as described, a flat soft camel-hair brush charged with the isinglass size should be passed lightly over the work; but not worked to and fro, or it will remove the gold leaf. The size should be flowed on freely and rapidly, and if any small pieces have been omitted, no attempt should be made to retouch them while the size is wet. When it is dry, the gilding will resume its brightness.

In order to complete the burnish of the gold, sometimes hot water is poured over the gilding, and this not only washes out any little specks which may appear on the front of the gold, but enhances its brilliancy considerably. The hotter the water poured over the work, the brighter does the gilding become, but care must be taken, as beyond certain degrees of heat the water will break the glass. The hot-water bath now is often dispensed with, and the size coated over the gilding is applied hot. This method is not quite so effective but it is much safer. The whole of the gilding has now to be repeated. A second layer of gold leaf over the first is necessary to ensure a satisfactory result. The second coat of gold is put on with the isinglass size, the same as the first; and as it dries, the gilding viewed from the front of the glass will present a rich and finished appearance. The loose pieces of gold are removed the same as with the first coat, by means of cotton-wool gently rubbed over the work. Another coat of size made hot may now be applied, and the gilding is ready to be written upon.

It is better to leave the gilding on for a day or two before writing upon it, because the isinglass does not get thoroughly hard, though to all appearance it is perfectly dry in an hour or two. If the gilding is left untouched for 2–3 months, the action of the spirits of wine will cause the gold leaf to adhere so firmly to the glass that it will be difficult to remove it by any amount of washing with water; whereas in the course of a few days after it is laid on, it may be readily removed by a damp sponge. There are several ways of transferring the outline of the writing to the gold. The most expeditious method is to rub some dry whiting over the front side of the writing, on the paper, place this over the gilding, face downwards, then go over the outline of the letters with a pointed stick or hard pencil. On removing the paper, it will be found that where the letters have been traced, the whiting has marked the gold.

Having an outline of the writing or design, next paint the letters with a sable writing pencil, and the ordinary japan black used by coach painters. If on turning the glass round it should be seen that the japan black deadens the gilding or is perceptible in any way on the front of the glass, another coat of size should be passed over the gold to prevent the black from coming through the gold leaf. When the japan black is hard, the superfluous gold must be washed off with a sponge and warm water. When the japan is dry, the edges of the letters may be cut sharp and true by passing a small chisel along a straight edge, so as to trim the writing, and make the tops and bottoms perfectly regular. All the straight lines of the letters may be thus trimmed, but the curved ones must be perfected with a writing pencil. The softened coloured thicknesses added to the letters are painted with the ordinary oil colours thinned with boiled oil and turpentine, the latter being used sparingly. Three or more tints are generally mixed on the palette, with a separate pencil to each, and these are softened with a larger sable pencil, and the outer edges are cut up with a pointed stick guided by a straight edge, whilst the colour is wet, and the superfluous colour is wiped off with a piece of rag. By this means a sharpness of outline is obtained which the most skilful writer would fail to get by the mere use of the pencil. The shadow is put on as soon as the thickness is dry, and not being softened down, quick drying colours may be employed.

Illumination on Paper, Vellum, etc.—(*a*) For illumination on a large scale, ordinary gilders' size can be used on stout paper. For fine work or water-matt, gold size is useful, but not easy to bring to a smooth surface. Clear gum arabic, used as thickly as is convenient for the paint-brush, makes a good ground for the gold leaf. The ordinary gilding size must be left till it is tacky, that is, all but dry. Having seen that the size is properly tacky, or having breathed on the water size or gum, lay the gold leaf on the work, pressing a piece of slightly-greased paper gently on with the fingers. In a few minutes take up the paper rather briskly from the work, and it should bring away all superfluous gold.

(*b*) Letters written on vellum or paper are gilded in three ways. In the first, a little size is mixed with the ink, and the letters are written as usual; when they are dry, a slight degree of stickiness is produced by breathing on them, upon which the gold leaf is immediately applied, and by a little pressure may be made to adhere with sufficient firmness. In the second method, some white-lead or chalk is ground up with strong size, and the letters are made with this by means of a brush; when the mixture is almost dry, the gold leaf may be laid on, and afterwards burnished. The last method is to mix up some gold powder with size, and to form the letters of this by means of a brush.

Ivory.—Ivory is not so easy to gild as articles made of wood: wood, being porous, retains a portion of the gold size; yet, on the other hand, bone or ivory may be so gilt that it shall resemble gold. Free the ivory from dirt or grease; when quite dry, give the article a thin coat of gold size laid on evenly with a fine hair brush; lay aside until set, which may be known by feeling whether tacky to the finger. The gold size should be just the least warm; the article may, with advantage, be warmed before applying the gold size; great care must be used to keep the dust from the article until gilt and quite dry. Cut the gold leaf in suitably sized pieces, and apply with the tip; the gold leaf may then be pressed into shape with a piece of white wool. Should any part appear not gilt, apply a dab of gold size, then a piece of gold leaf. When quite dry, it may be burnished with an ivory paper-knife, or even a glass pen-holder, always inserting a piece of tissue paper between the burnisher and the article that is gilt. When finished off, the appearance will be much improved by giving the article a coat of gold lacquer.

Japanned Work is where ornaments are drawn in gold upon japanned work, and is often seen in folding screens and cabinets. The ornaments are formed by a camel-hair pencil, with japanners' gold size, made by boiling linseed-oil with gum anime, and a little vermilion. When the size is nearly dry, gold powder or gold leaf is applied. In all cases where gold has been fixed on by means of linseed-oil, it will bear being washed without coming off. (*See* JAPANNING.)

Leather.—In order to impress gilt figures, letters, and other marks upon leather, as on the covers of books and edgings for doors, the leather must first be dusted over with very finely powdered dried white of egg, yellow rosin, or mastic gum, upon which lay a leaf of gold. The iron tools or stamps are now arranged on a rack before a clear fire, so as to be well heated, without becoming red hot. If the tools are letters, they have an alphabetical arrangement on the rack. Each letter or stamp must be tried as to its heat, by imprinting its mark on the raw side of a piece of waste leather. A little practice will enable one to judge of the heat. The tool is now to be pressed downwards on the gold leaf, which will, of course, be indented, and show the figure imprinted on it. The next letter or stamp is now taken or stamped in like manner, and so on with the others; taking care to keep the letters in an even line with each other, like those in a book. By this operation the rosin is melted; consequently, the gold adheres to the leather; the superfluous gold may then be rubbed off by a cloth, the gilded impressions remaining on the leather. The cloth alluded to should be slightly greasy, to retain the gold wiped off; the cloth will thus be soon completely loaded with the gold. When this is the case, these cloths are generally sold to the refiners, who burn them and recover the gold.

Masonry.—The porous surface of stone or plaster must first be rendered waterproof and "satisfied" by coats of either a solution of shellac and gutta-percha in naphtha, or of shellac in methylated spirit, great care being taken that the surface is previously dry, and that the oil size afterwards applied does not extend beyond the "satisfied" portion.

Metals.—The application of a gold coating on various substances is performed by three separate methods, viz. by amalgamation, by dipping, and by cementing.

BY AMALGAMATION. *Gold Amalgam.*—(*a*) In the centre of a charcoal stove put a crucible holding a given quantity of pure and dry mercury, and when the temperature has reached about 212° F., add $\frac{1}{8}$ the weight of gold. Stir with an iron rod until the amalgam has acquired the consistency of butter, throw it into cold water, and keep it there for use.

(*b*) A quantity of mercury is put into a crucible or iron ladle, which is lined with clay, and exposed to heat till it begins to smoke. The gold to be mixed should be previously granulated, and heated red hot, when it should be added to the mercury, and stirred about with an iron rod till it is perfectly dissolved. If there should be any superfluous mercury, it may be separated by passing it through clean soft leather; and the remaining amalgam will have the consistency of butter, and contain about 3 parts of mercury to 1 of gold.

Applying Amalgam.—The metal to be gilt is previously well cleaned on its surface, by boiling in a weak pickle of very dilute nitric acid. A quantity of aquafortis is poured into an earthen vessel, and quicksilver is put therein; when a sufficient quantity of mercury is dissolved, the articles to be gilt are put into the solution, and stirred about with a brush till they become white. This is called quicking. During quicking by this mode a noxious vapour continually arises, which proves very injurious to the health of the workmen. To avoid that danger, dissolve the quicksilver in a bottle containing aquafortis, and leave it in the open air during the solution, so that the noxious vapour escapes into the air. Then a little of this solution is poured into a basin, and with a brush dipped therein stroke over the surface of the metal to be gilt, which immediately becomes quicked. The amalgam is now applied by one of the following methods:—

(*a*) By proportioning it to the number of articles to be gilt, and putting them into a vessel together, working them about with a soft brush, till the amalgam is uniformly spread.

(*b*) By applying a portion of the amalgam upon one part, and spreading it on the surface, if flat, by working it about with a harder brush. The work thus managed is put into a pan, and exposed to a gentle degree of heat; when it becomes hot, it is frequently put into a pan, and worked about with a painters' large brush, to prevent an irregular dissipation of the mercury, till at last the quicksilver is entirely dissipated by the repetition of heat, and the gold is attached to the surface of the metal. This gilt surface is well cleaned by a wire brush, and then artists heighten the colour of the gold by the application of various compositions, this part of the process is called colouring.

(*c*) Mercury gilding will furnish gold with a bright or a dead lustre, scratch-brushed, or-molued, and with different shades. The amalgam should be about as hard as wax. This amalgam is crystalline, and a certain crackling sound is heard when the crystals are crushed between the fingers. A stock of amalgam is generally prepared in advance, and is divided into small balls of nearly equal size, the value of which is ascertained from their number and from the total weight of gold employed. These balls are kept in water, but should not remain too long without being used, as the different parts do not then present the same composition. The amalgam is spread with the finger upon a flat, hard stone, called the gilding stone; and, having dipped a scratch-brush of stout brass wire into a solution of nitrate of binoxide of mercury until it becomes completely white, it is passed over the amalgam, a portion of which is carried away. The object, previously well cleansed, is scratch-brushed in every direction, and the brush must be frequently dipped into the mercurial solution to facilitate the regular and even spreading of the amalgam. This operation requires great care to obtain a uniform coat upon the hollow and raised parts. When the back part of a piece does not require gilding, the flat outline, and the back edge, should be gilt, so that the naked copper shall cause no injury in the subsequent operations. The article, when uniformly covered with the amalgam, is heated upon a charcoal fire without draught, which rests upon a cast-iron plate. It is advisable to employ a gilding forge, which allows the workman to watch the operation from behind a glass frame, which protects him from the mercurial vapours. The entire attention is now required for watching the process. With the left hand, covered with a thick glove of buckskin, turn the piece in every direction upon the fire, and, as the mercury disappears, with the right hand strike the article in every direction with a brush, the handle and the bristles of which must be long, to equalise the gilding, and to push the remaining amalgam upon those parts which appear less charged with it. When all the mercury has volatilised, the gilding has a dull greenish-yellow colour, resembling that of boxwood; examine whether the coat of gold is continuous. Should a few empty places appear, add more amalgam, and heat the whole again. The next operation is scratch-brushing, which furnishes a pale green colour, and requires another heating for arriving at the desired shade. The reheating should expel any remaining mercury, and produce a fine orange-yellow colour. In case a bright lustre is required, submit the object, with the aid of heat, to the or-molu process. To obtain dead lustre, the object is firmly fixed to an iron rod, by wire of the same metal, and smeared with a hot paste for dead gilding, composed of saltpetre, common salt and the double sulphate of alumina and potash. The whole is heated upon a brisk charcoal fire, without draught, and moved about until the mixture dries and begins to fuse, when the article is immediately placed in a barrel half filled with water. The covering of salts dissolves, and the dead lustre appears; this operation requires a certain amount of practice. The gilding must be strong to stand the dead lustre process, especially when the first trial is not successful. The red lines left by the iron wire disappear by plunging the object into a not too diluted solution of nitric acid, or pure hydrochloric acid. Mercury gilders do not employ pure gold; what they use is previously alloyed with a certain portion of copper or silver. With the latter metal the gilding is green.

(*d*) *Grecian Gilding.*—Equal parts of sal-ammoniac and corrosive sublimate are dissolved in spirit of nitre, and a solution of gold is made with this menstruum. Silver brushed over with it turns black, but on exposure to a red heat it assumes the colour of gold.

Gilding in Colours.—The principal colours of gold for gilding are red, green, and yellow. These should be kept in different amalgams. The part which is to remain of the first colour, is to be stopped off with a composition of chalk and glue; the variety required is produced by gilding the unstopped parts with the proper amalgam, according to the usual mode of gilding. Sometimes the amalgam is applied to the surface to be gilt, without any quicking, by spreading it with aquafortis; but this depends on the same principle as a previous quicking.

Cold Gilding with the Rag.—Dissolve finely laminated pure gold in aqua regia made of 5 parts nitric acid, 2 sal-ammoniac, ⅛ saltpetre. Heat carefully upon a gentle fire; when all the gold has disappeared, pour the cooled contents of the flask into a flat-bottomed stoneware pan. Into this liquor place one upon the other, and in sufficient quantity, squares of linen cloth; strike them with a glass rod, in order that they may equally absorb the gold chloride. Each square of cloth is taken out with wooden pincers, well drained, and spread for drying in a dark chamber. When nearly dry, each piece of cloth, supported upon glass rods, is placed on top of a charcoal fire, and soon takes fire. The combustion is aided by the presence of the saltpetre, and is finished upon a marble slab. Grind the ashes under a muller, collect and keep them between the folds of a parchment leaf, around which a wet cloth has been folded. The powder is then ready to use; mix it upon a slab with a few drops of water, and with this paste rub the well-cleaned surfaces of the silver to be gilt. The smooth surfaces are rubbed with the thumb, the fillets or grooves with a fine cork cut to the proper shape, and the corners or angles with a stick of soft wood, such as linden or poplar; the articles are then burnished. This gilding is very thin, but quite resisting, especially after the action of the burnishing tool, which forces the gold into the pores of the silver. If a red shade be desired, add a small proportion of pure copper to the gold to be dissolved in aqua regia.

Gilding with a Dead Lustre.—(*a*) By the slow deposit of a large proportion of gold. This gilding is very durable, but dull and earthy in appearance, and is costly.

(*b*) By acids; giving a dead lustre to the metallic surface, before gilding, and by the processes indicated in the cleansing operations. This is employed for small articles, or when gilding by dipping, for bronze articles, or large embossed work.

(*c*) With frosted silver, by depositing upon the object to be gilt a coat of frosted silver, and then gilding in a good bath; this method is expensive, the burnished parts are greenish, and the intermediary coat of silver is more easily blackened by sulphur fumes than gold.

(*d*) By decomposing a solution of copper sulphate by a battery, depositing a coat of this metal, which possesses a pink dead lustre. The whole is rapidly passed through the compound acids for a bright lustre, and the mercurial solution, and then gilt in a good bath. When the dead lustre obtained in the bath is perfect, the compound acids may be dispensed with, and merely place the article in the mercurial solution before it is gilt. This mode is generally preferred, as the gilding is very handsome in lustre and colour. The burnished parts will be red, if vinegar or soap-water is used; and of a fine yellow colour, if the burnishing tool be wetted with a decoction of flax-seed, or of marsh-mallow root. If the gold deposit is of insufficient thickness, it will blacken in time, by the oxidation of the intermediate coat of copper.

(e) Mercury furnishes the most durable gilding, although costly.

(f) For Zinc.—With tin solder fill all the holes and the smallest defects which may exist in the zinc object, and, at the same time, remove all seams, burrs, and rough spots. Afterwards, scour the piece by passing it, for a few seconds only, through a boiling solution of 100 parts water and 5–6 caustic soda; if left too long in this caustic lye it will spoil the polish of the zinc, which dissolves. After this scouring, the object is rinsed in fresh water. It is then steeped for ½ minute in a pickle composed of 1 part sulphuric acid and 10 water, and lastly rinsed in boiling water. Then place the object in a cold or warm electro bath of copper or brass for a few moments, until it is covered with a thin metallic coating, which is deposited very uniformly if the object has in it no tin solder and is perfectly cleansed; the deposit is black and dull on those parts which have been soldered or imperfectly cleansed. In this case, thoroughly scratch-brush the article, and dip again into the electro-bath until the deposit is sufficiently thick. Most gilders use a warm bath for the first coating, scratch-brush, and complete the deposit in a cold bath. If a bright gilding is desired, the article may be rinsed in fresh water, and then dipped into an electro-gilding bath.

Gilding with a partly Dead, partly Bright Lustre.—(a) Gild those parts with the amalgam which are intended for a dead lustre, and heat, scratch-brush, and reheat to the orange-yellow colour. Then, with the battery, give a sufficiently strong gold deposit to the whole, without regard to the parts already mercury-gilt; scratch-brush all the surfaces carefully, and smear the electro-gilt portions first with a thin mixture of water, glue and Spanish white, and afterwards with a thick paste of yellow clay. After drying, cover the mercury-gilt portions with the paste for dead gilding, and proceed as already described. The Spanish white, etc., are dissolved in a dilute solution of hydrochloric acid. The glued paste is to preserve the electro-gilt portions from the heat; these are again wire-brushed with all the care necessary for not scratching the dead lustre. Brushing to finish. This method will sometimes produce red spots on those places which have been heated too much, or where the coat of gold was not thick enough.

(b) Gild with the amalgam, and bring up the dead lustre upon those portions which are to receive it, and preserve them entirely with the resist varnish. After thorough drying, cleanse the object by dipping it into acids, in the usual manner, and gild in the electro-bath. The resist varnish stands all these acids and solutions. When the desired shade is obtained, dissolve the varnish with gasolene or benzine, which, unless there has been friction applied, does not injure either the shade or the velvety appearance of the dead lustre. Wash in a hot solution of potassium cyanide, then in boiling water, and allow to dry naturally. The resist varnish may also be removed by allowing the object to remain for a time in concentrated sulphuric acid at 66° B., which has no action whatever upon the gilding. In this case, washing with cyanide is unnecessary, pure water is sufficient. Gilding with a dead lustre, whatever process is employed, only suits those objects which will never be subjected to friction. Even the contact of the fingers injures it. A new freshness is imparted to old dead gildings by a washing in caustic lye, and then in a dilute solution of nitric or sulphuric acid. This process removes dirt, grease, dust, and smoke, but will not remedy scratches. In the latter case, the objects must be scratch-brushed, and then heated with the composition for a dead lustre.

Covering Copper Bars with Gold, so as to be rolled out into Sheets.—First prepare ingots or pieces of copper or brass, in convenient lengths and sizes. Then cleanse them from impurity, and make their surfaces level. Prepare plates of pure gold, or gold mixed with a portion of alloy, of the same size as the ingots of metal, and of suitable thickness. Having placed a piece of gold upon an ingot intended to be plated, hammer and compress them both together, so that they may have their surfaces as nearly equal to each other as possible; then bind together with wire, in order to keep them in the same position during the process required to attach them. Afterwards mix silver filings with borax, to assist the fusion of the silver. Lay this mixture upon the edge of the plate, and next to the ingot of metal. Having prepared the two bodies, place them on a fire, where they must remain until the silver and borax placed along the edges of the metals melt, and until the adhesion of the gold with the metal is perfect. Remove the ingot carefully from the stove. By this process the ingot is plated with gold, and prepared ready for rolling into sheets.

BY DIPPING.—It is not always necessary in electrogilding to use a battery, for a salt or acid liquor is enough to produce electricity; thus it is sufficient to plunge the articles, attached by zinc wires, into gold baths prepared for the use of batteries, to have the operation taking place in the same manner as with a separate battery. Electrogilding in the cold is employed for large pieces, such as clocks; whilst electrogilding by heat is more adapted to the gilding of small articles, such as forks and spoons. The deposits produced by hot gilding are more smooth and clean, the colour is deeper, and the articles when removed from the bath may not require colouring; and with the same quantity of gold, gilding by heat is much more durable than that obtained from cold baths. Steel, tin, or lead can be gilt in hot baths, but not in cold.

Silver by Dipping.—The silver articles, previously cleansed and scratch-brushed, are boiled for about ½ hour in the gold bath of pyrophosphate, to which add a few drops of sulphurous acid, or, preferably, hydrocyanic acid, in excess of the quantity needed by the primitive bath. This gilding is very fine, but without firmness. The deposit is rendered more rapid and thicker when the silver articles are stirred with a rod of copper, zinc or brass.

Preparing Silver Parts.—Marks of the file are obliterated by a rubbing upon a wet stone, and lastly upon an oilstone. Any oil or grease is removed by boiling the parts for a few minutes in a solution made of 100 parts water and 10 of caustic soda or potash; rinse in clean water, which should wet them entirely if all the oil has been removed. The articles are threaded upon a brass wire; cleanse them rapidly in the compound acids for a bright lustre, and dry them carefully in white wood saw-dust. The pieces are fastened upon the even side of a block of cork by brass pins with flat heads. The parts are then thoroughly rubbed over with a brush entirely free from grease, and charged with a paste of water and very fine pumice powder. Move the brush in circles, in order not to rub one side more than the other; thoroughly rinse in clean water, and no particle of pumice should remain upon the pieces or the cork. Next place the cork and the pieces in a weak mercurial solution, which very slightly whitens the copper, composed of—water 2⅕ gal., nitrate of binoxide of mercury $\frac{1}{14}$ oz., sulphuric acid ¼ oz. The pieces are passed quickly through the solution, and then rinsed. This operation gives strength to the graining, which, without it, possesses no adherence.

Silver Powder.—Silver powder is obtained by immersing cleansed copper plates in a very dilute solution of silver nitrate made with distilled water. The more dilute the solution is, the finer is the precipitate of silver upon the copper, and the more easily it is removed. In a glass or porcelain vessel, ⅔ oz. crystallised silver nitrate are dissolved in 2⅙ gal. distilled water, and 5 or 6 bands of cleansed copper, ¾ in. wide, are placed in it. These bands should be long enough to allow of a portion being above the liquid. The whole is kept in a dark place for 24 hours, and now and then stirred with the copper bands. This motion is sufficient to loosen the deposited silver, and present fresh copper surfaces to the action of the liquor. When no more silver deposits on the copper, the operation is completed, and there remains a blue solution of copper nitrate. The silver powder is washed by decantation, or upon a filter, until there remains nothing of the copper solution. It is then carefully dried, avoiding contact with hard bodies. Nuremberg powder is produced by grinding a mixture of honey and silver foil upon a ground-glass plate with a muller until the proper fineness is obtained. The silver is separated by dissolving the honey in boiling water, and washing the deposited metal in a filter, until there is no remaining trace of honey. The silver is then carefully dried at a gentle heat.

Steel.—(*a*) Dissolve any quantity of gold or platinum in nitro-muriatic acid, until no effervescence is occasioned by the application of heat. Evaporate the solution thus formed to dryness in a gentle heat, and re-dissolve the dry mass in as little water as possible; next take an instrument which is used by chemists for dropping liquids, known by the name of a separating funnel, having a pear-shaped body tapering to a fine point, and a neck capable of being stopped with the finger or a cork; fill it with the liquid about one quarter part, and the other three parts must be filled with the very best sulphuric ether. If this is rightly managed, the two liquids will not mix. Then place the tube in a horizontal position, and gently turn it round with the finger and thumb. The ether will very soon be impregnated with the platinum or gold, which may be known by its change of colour. Replace it in a perpendicular position, and let it rest for 24 hours, having first stopped the upper orifice with a small cork. The liquid will then be divided into two parts; the darker coloured being underneath. To separate them, take out the cork, and let the dark liquid flow out; when it has disappeared, stop the tube immediately with the cork; and what remains in the tube is the gilding liquid. Let it be put into a bottle, and tightly corked. When an article is to be gilded, a vessel of glass or unglazed ware must be provided, of just sufficient size to admit the article; it must then be filled with the gilding liquid, nearly to the top. The steel must be very highly polished, and entirely free from rust or grease. A basin, full of clean water, must be ready at hand, the article is immersed in the gilding liquid, and quickly removed; then quickly plunged into the water, and well rinsed; next dried with blotting paper, and placed in a temperature of 150° F. till it be completely heated throughout; it may then be polished with rouge and a soft leather, or be burnished. Pure gold must be employed. The ethereal solution may also be concentrated by gentle evaporation. Care must be taken not to wipe the steel until the heat has been applied. This gilding is an effectual protection against rust, and is very ornamental.

(*b*) Make a solution of 8 oz. nitre and common salt, with 5 oz. crude alum in a sufficient quantity of water; dissolve 1 oz. gold thinly plated and cut; and afterwards evaporate to dryness. Digest the residuum in rectified spirit of wine or ether, which will perfectly abstract the gold. The iron is to be brushed over with this solution, and becomes immediately gilt.

Watch Parts.—In gilding small articles for watchmakers, gold is seldom directly applied upon the copper; there is generally a preliminary operation, called graining, by which a grained and slightly dead appearance is given to the articles.

Graining.—A thin paste made of one of the graining powders and water is spread by means of a spatula upon the watch parts held upon the cork. The cork itself is placed upon an earthenware dish, to which a rotating movement is imparted by the left hand. An oval brush, with close bristles, held in the right hand, rubs the watch parts in every direction, but always with a rotary motion. A new quantity of the paste is added two or three times, and rubbed in the manner indicated. The more the brush and the cork are turned the rounder becomes the grain, which is a good quality; and the more paste added the larger the grain. When the desired grain is obtained, the pieces are washed and then scratch-brushed. The wire brushes employed, which usually come from Nuremberg, are made of brass wires as fine as hair, very stiff and springy. It is necessary to anneal them upon an even fire to different degrees: one soft, or half annealed, for the first operation or uncovering the grain; one harder, for bringing up the lustre; and one very soft, or fully annealed, used before gilding for removing any marks which may have been made by the preceding tool, and for scratch-brushing after the gilding, which, like the graining, must be done by giving a rotary motion to the tool. Decoctions of liquorice or saponaire are employed in this operation.

Graining Powders.—(*a*) Silver in impalpable powder, 1 oz.; cream of tartar, finely pulverised and passed through a silk sieve, 10 oz.; common salt, pulverised and sifted as above, 2 lb.

(*b*) Silver powder, 1 oz.; cream of tartar, 4–5 oz.; common salt, white and clean, 13 oz.

(*c*) Silver powder, 1 oz.; cream of tartar, 3 oz.; common salt, white and clean, 2 lb.

All these substances should be as pure as possible, and perfectly dry. Cream of tartar is generally dry; common salt often needs, before or after it has been pulverised, a thorough drying in a porcelain dish, in which it is kept stirred with a glass rod. The mixture of the three substances must be thorough, and effected at a moderate and protracted heat. The graining is the coarser the more common salt there is in the mixture; and it is the finer and more condensed as the proportion of cream of tartar is greater, but it is then more difficult to scratch-brush.

Resists.—(*a*) If it happens that the same watch part is composed of copper and steel, this latter metal requires to be preserved against the action of the cleansing acids and of the graining mixture, by a composition called resist. This consists in covering the pinions and other steel parts with a fatty composition, which is sufficiently hard to resist the tearing action of the bristle and wire brushes, and insoluble in the alkalies of the gilding bath. Yellow wax, 2 oz.; translucent colophony, 3⅓ oz.; extra fine red sealing-wax, 1⅓ oz.; impalpable iron peroxide or polishing rouge, 1 oz. Melt the colophony and sealing-wax in a porcelain dish upon a water bath, and afterwards add the yellow wax. When the whole is thoroughly fluid, gradually add the rouge, and stir with a wooden or glass rod. Withdraw the heat, but continue the stirring until the mixture becomes solid, otherwise all the iron oxide will fall to the bottom of the mixture. The flat parts to receive this resist are slightly heated, and then covered with the mixture, which melts and is easily spread. For covering steel pinions, employ a small gouge of copper or brass fixed to a wooden handle. The metallic part of the gouge is heated upon an alcohol lamp, and a small quantity of resist is taken with it. The composition soon melts, and, by turning the tool around the steel pinion, this becomes coated. Use a scratch-brush with long wires, as their flexibility prevents the removal of the composition. When the resist is to be removed after gilding, place the parts in warm oil or tepid turpentine, then in a very hot soap-water or alkaline solution, and, lastly, in fresh water. Scratch-brush and dry in warm saw-dust of white wood. The holes of the pinions are cleaned and polished with small pieces of very soft white wood, the friction of which is sufficient to restore the primitive lustre. The gilding of parts composed of copper and steel requires the greatest care, as the slightest rust destroys their future usefulness. Should some gold deposit upon the steel, it should be removed by rubbing with a piece of wood and impalpable pumice-dust, tin putty, or rouge.

(*b*) When it is desired to obtain gildings of several colours upon the same object, resists, generally made of some kind of varnish, are used. After having gilt an article of a uniform red or green colour, it is covered with a fat varnish, made drying by the addition of lead chromate, at those places which are to resist the action of the new bath. By means of resists and successive baths, several different shades can be obtained upon the same object. The resist varnishes are applied with a brush or pencil, and should be thoroughly dried in a stove before placing the object in another solution. These varnishes may be coloured with various oxides or coloured salts, in order to facilitate their use upon those places which should be sharply marked; lead chromate and artificial ultramarine blue are well suited for the purpose. Resist varnishes are also used for preserving the reverse parts of articles which have to receive the gilding only on the front. When the operation is finished, the resist is easily removed by washing, first with essence of turpentine, gasoline, benzine, or benzole, and then with alcohol; when benzole is used, it is sufficient to wash the article in boiling water, and then to dry it in warm saw-dust of fir-wood. It comes out perfectly clean. This is not always the case with rectified turpentine, and it may be necessary to plunge the object into a hot alkaline lye, then to rinse and dry it in warm saw-dust.

Oil Gilding, *see* **Wood.**

Or-molu.—This operation consists in smearing, by means of a brush, the gilt and scratch-brushed objects with a thin paste of potash nitrate, alum, and iron oxide, which have been well mixed and ground under the muller, and to which has been added a solution of saffron, annatto, or any colouring substance according to the shade desired. If the gilding is strong and thick, the objects are heated until the previous coating curls over at the approach of a wet finger. If the gilding is a mere film, the mixture is simply allowed to stand upon the articles for a few minutes. In either case, the whole is rapidly washed in warm water holding in suspension a certain quantity of the materials for or-molu; they are then rapidly dried, when they appear of a darker shade; remove any portions too much coloured, by striking them vertically with a brush having long bristles. If the tint does not appear satisfactory, commence the operation afresh, after washing off the or-molu in dilute sulphuric acid.

Paint.—The paint must first be thoroughly dry. The letters must be written on the paint with gold size, and allowed to get a little dry, or else the writing will appear dull. Now press the gold leaf on the size, and rub it down with a piece of cotton-wool. If by accident there is more than one thickness of gold it will appear dull.

Paper-hangings. — The part which is to show the gilt is first printed in common size mixed with a little water; when dry, rolled up and reprinted in gold size, and as it is being printed the piece is drawn out from the table into a trough, tech-called a drum, and then the metal, which is Chinese bronze, is slightly laid over the surface and the drum is tapped underneath with a common cane, which causes the metal to adhere to the gold size; it is then carefully drawn out of the drum and hung up till dry, then rolled up; to improve the appearance, the hangings are passed between two embossing rollers, which give the smooth finish.

Picture Frames. — The wood moulding is made by the joiner into 12 ft. lengths, and in that state it passes into the hands of the gilder. He first gives it a priming of hot size and whiting, called thin white. The whiting employed by the gilder is not the same as that used for domestic purposes, but is finer and more free from grit. The size employed is prepared by the gilder from parchment or glove cuttings. The cuttings are well washed in water, and then boiled in a certain quantity of clean water, until the latter has a particular degree of adhesiveness, which can only be determined by experience; this is then poured off into a clean dry vessel, and allowed to cool.

When about to be used, the grease at the top and the sediment at the bottom are cut off with a knife, the size is melted in an earthen pipkin, and a small quantity of finely-powdered whiting is mixed up with it. When the thin white is dry, all holes and irregularities in the moulding are filled up with putty. This putty is not the same as that employed by the glazier, but consists of whiting and size mixed to the consistence of putty. When the putty is dry, a coating of thick white is laid on with a brush. This thick white differs from the thin white only in having a larger proportion of dry whiting mixed with a given amount of size, the consistence attained being rather thicker than that of oil paint. When the first thick white is dry, another is laid on in the same manner, and, similarly, a third, a fourth, and a fifth, are laid on, all about equal in thickness, and each one being perfectly dry before the next is applied.

As in laying on this large body of thick white, the fine squares, hollows, and fillets would be liable to be stopped up and lose all their clearness and sharpness, opening tools, consisting of crooks, chisels and gouges, are drawn along the fine parts of the moulding, while the thick white is still wet; by which means the forms of the various mouldings are retained. This is still better effected by the double opening white, which consists of two thick whites; the one laid on almost immediately after the other, by which a thick soft coating covers the moulding. Hard stones, shaped to the forms of the mouldings, together with the opening tools before described, are to be worked over every part of the moulding, by which asperities are smoothed down, depressions filled up, and edges brought up nearly to their required sharpness. In this state the whiting on the moulding is $\frac{1}{16}$-$\frac{1}{12}$ in. thick. It is now trimmed at the back and edges by cutting off the whiting which has flowed over from the front, which prepares it for the process of smoothing. This is done by means of pieces of pumice and other stones, shaped so as to fit the various parts of the moulding. A sponge or soft brush is used to wet the moulding, and the stone which is to be used, being likewise wetted, is rubbed or worked to and fro along the moulding until that part is perfectly smooth. Another stone, fitting a different part, is then used in the same way; and so on, until every part of the length and breadth of the moulding has been worked over by the stones.

The moulding, if the smoothing has been properly performed, now presents a smoothness of surface exceeding, and a keenness of the edge nearly equalling, that which the moulding presented when it left the hands of the joiner; but this must be attained without rubbing off too much of the whiting, since the whole beauty of the frame mainly depends on having a sufficient body or foundation of whiting. The brilliant burnishing on frames is, in a peculiar degree dependent on the whiting which is laid on the wood, and which, if deficient in quantity, cannot be adequately replaced by other means. The moulding, being thoroughly dried from the effects of the smoothing, is rubbed down with fine glass- or sand-paper, to take off any little asperities that may remain, and to make the whole perfectly smooth. It is now ready for the process of gold-sizing.

The burnish gold size used in this process is composed of ingredients exceedingly opposite in their nature, such as pipe-clay, red chalk, black-lead, suet, and bullock-blood. This diversity of ingredients is intended to produce different effects; one substance helps to give a brilliancy to the burnish, another to the mellowness and smoothness, and so on. The form in which the gilder purchases his burnish gold size is that of a solid rather softer than butter. He first takes some very clear size, boiled purposely to a smaller degree of strength than the size for thick white, or, if already boiled, weakened by water. This size he melts in an earthen pipkin, but without making it very hot, and then mixes the gold size with the melted size by means of a clean brush, much in the same manner as a painter mixes his oil paint; the consistence to be about equal to that of cream.

It is a source of some confusion that the same term, burnish gold size, is applied to this creamy liquid, as to the thicker substance from which it is prepared; it is necessary to say mixed gold size, or unmixed gold size, in order to indicate which is meant. This gold size is laid on the moulding either with a very soft hog-hair brush, or by a large camel-hair pencil, fixed in a swan quill. The gold size must be barely warm, and must be laid on with great care so as to leave it equally thick in every part, and obliterate the marks of the brush; upon the due observance of a medium between hot and cold, strong and weak, and thick and thin, in the gold size laid on, depends much of the beauty of the moulding when gilt. From 4 to 8 coats of this gold size are laid on the moulding, each one being perfectly dried before the next is applied. A soft, partially worn piece of glass-paper is occasionally used, to take off any roughness that may exist.

When a sufficient body of gold size is laid on, it is carefully washed with clean water, a soft sponge, and a piece of linen rag. This must be done with attention to the soft edges, which are very likely to lose the whole of their gold size if care is not used; the object is to produce a perfectly smooth surface, especially in those parts which are to be matt gold. The test of good work is to produce the smoothest surface with the least loss of gold size. When the moulding is partially dry from this process, the matt parts are polished with a piece of woollen cloth, and the parts to be burnished receive another coating of gold size, laid on as smoothly as possible. The piece of moulding which is to be gilt is laid along the bench with one end higher than the other; and as the width of the moulding is broken up into several divisions, such as hollows and squares, it would be impossible to make a leaf of gold bend into all the various parts without breaking.

The gilder learns by experience how many separate lays, as they are called, of gold will be required to cover the width of the moulding without the breaking of the gold into irregular fractures called spider-legs. In general, a deep hollow, or a depressed square, cannot be gilt at one lay, but must be covered with two strips of gold, laid side by side and meeting at the centre of the depression. When the gilder has made his decision as to the number of lays that will be required, he selects one lay, and proceeds with it through the whole length of the moulding before he begins another portion of the width.

If the necessary lay be about ¾ or ⅞ in. wide, he cuts the leaf which is spread out on his cushion into 4 strips; if it be about 1 in. wide, he cuts the leaf into 3, regulating the division of the leaf of gold according to the width of the lay. It is not often that a larger piece than half a leaf is used at once. The gilder has at hand a pan with clean water, and 2 or 3 camel-hair pencils of different sizes. With one of these pencils he wets a few inches of that part of the moulding which is to form his first lay, taking care not to wet much beyond that lay. The water is to be allowed to remain pretty full on the surface, after some of it has been imbibed by the gold size. The gilder then takes his tip in his right hand, and lays it on the slip of gold, which slightly adheres to the hairs; whence he places it on the moulding, with particular attention to straightness of direction. It frequently happens that the hairs of the tip will not take up the gold; in such case it is usual to rub the hairs between the cheek and the palm of the hand, by which their power of taking up the gold is increased.

When the gold is laid on it is blown forcibly, to expel as much of the water as possible from beneath it, the dry camel-hair pencil being used to press down any parts which fail to adhere. Another portion is then wetted, and another piece laid on, lapping about $\frac{1}{8}$ in. over the end of the former piece. Thus the gilder proceeds, piece after piece, until the one lay is carried down the whole length of the moulding; he then proceeds with another lay joining the former. In doing this he has to observe that the water must be made to flow a little over the edge of the former lay, but not so as to wash it up, or break away the edge; the second lay must lap a little over the first, and therefore the water must likewise extend over the first lay. Thus he proceeds with all the lays into which he has found it necessary to divide the width of the moulding; every piece, lengthwise, lapping over the piece previously put on, and every lay lapping over the previous lay. The moulding is then set aside to dry. There is a particular state or degree of dryness, known only by experience, in which the moulding is in a fit state for burnishing. The burnishers used by the gilder are either of flint or agate, generally the former; the steel burnishers employed by the jeweller would not do for the gilder.

Burnishers of different forms and sizes must be employed, in order to adapt them to the part of the work which is being burnished; they are generally crooked or curved near the end. When the burnishing is done, those parts which have not been burnished are weak sized, that is, they are wetted with water in which a very little clear piece of size has been melted; this helps to secure the gold. When dry, the gold is wiped carefully with a piece of soft cotton-wool, to remove rough or ragged edges of gold; and there are now visible a number of little breaks, holes, and faulty places in the gilding, arising from the impossibility of laying on the gold quite soundly and perfectly. These defective parts are repaired by the process of faulting, which consists of cutting up a leaf of gold into small pieces and laying them on the faulty places, previously wetted, with a camel-hair pencil. If the defective part is on the burnish, it is necessary to be careful not to wet any part but what is to be covered by the gold, as it will stain the burnished gold.

When the faulting is dry, the gold is again carefully wiped, and finally wetted with finishing size. This is clear size of a certain degree of strength, laid on the matt parts with a pencil, and completes the process of gilding. When a glass frame is to be gilt, the joiner's work is generally quite completed before the gilder begins, and great care is required in whiting such frames, to prevent filling up the corners with whiting, and giving them a clumsy apppearance. For this purpose, modelling tools, such as chisels, gouges, and crooks, are used to clear out the corners from time to time, and preserve the original sharpness and clearness of the several parts.

Composition for Picture-Frame Mouldings.—(*a*) The following is used by gilders: Mix 14 lb. glue, 7 lb. rosin, $\frac{1}{4}$ lb. pitch, $2\frac{1}{2}$ pints linseed-oil, 5 pints water, more or less according to the quantity required. Boil the whole together, well stirring until dissolved, add as much whiting as will render it of a hard consistency, then press it into the mould, which has been previously oiled with sweet oil. No more should be mixed than can be used before it becomes sensibly hard, as it will require steaming before it can be used again.

(*b*) Make a very clear glue with 3 parts Flanders glue and 1 part isinglass by dissolving the two kinds separately in a large quantity of water, and mix them together, after they have been strained through a piece of fine linen to separate the parts which could not be dissolved. The quantity of water cannot be fixed, because all kinds of glue are not homogeneous, so that some require more than others. The proper strength may be found by suffering the glue to become perfectly cold; it must then barely form a jelly. The glue is gently heated, then mixed with saw-dust sifted through a fine sieve. The moulds are then oiled with nut oil, and the mixture is pressed into the mould, covered with a weighted board, and then set to dry near a stôve. When the moulding is dry, it can be trimmed.

Burnished Gilt Frames.—When new burnished gilding requires varnishing, white hard spirit-varnish is used, or yellow gold lacquer. Old burnished work must be cleaned with great care. First remove the dust with a badger-hair brush; afterwards clean the gilding by passing a clean sponge dipped in gin and water, lightly over the surface, wiping off the moisture with a very soft dry sponge or silk handkerchief; then apply the varnish, and finish.

Cleaning Gilt Frames.—Gilt frames may be cleaned by simply washing them with a small sponge, wet with urine, hot spirits of wine, or oil of turpentine, not too wet, but sufficiently to take off the dirt and fly marks. They should not be afterwards wiped, but left to dry of themselves.

Various methods are employed by painters and gilders to clean old gilt work. Some wash the work well with a brush or sponge, which is sufficient in cases where the ground is firm, hard, and of a metallic colour; but where the grounds are absorbent, with gold letters, simply washing with water is in general insufficient. In such cases, employ an alkaline lye, made by dissolving 2 oz. pearlash in 3 pints water; then wet the work over with a brush or sponge dipped in the lye; let it remain some time, afterwards, with the sponge and clean water, wash off a part to see if the surface or gilding is properly clean, when it must be thoroughly washed with plenty of pure water, and wiped dry with a soft cloth or silk handkerchief. Oil of vitriol and water mixed until its acidity is equal to that of vinegar, is very cleansing, but requires considerable practice to apply it equally to the work, and it must not remain on too long, otherwise it will not only remove the dirt, but also the paint and gilding; it requires to be used with caution, frequently applying the sponge and clean water, in order to discover whether the surface is clean. When it is well washed and wiped dry, let the work stand to dry, and afterwards apply one or two coats of copal varnish. In revarnishing old work exposed to the weather, it is best to clean it over-night, and if the weather is fine next morning, and no appearance of rain, high wind, or dust, apply the varnish about sunrise, when the warmth of the sun will cause it to flow, set, and dry quickly and hard.

Re-gilding Frames.—(*a*) Take a sponge and some clean water, and wash the frame well; let it dry; procure some water-gold size; make some thin size from dry hide or parchment; mix enough warm with the gold size to enable you to work it on the frame with a camel-hair brush; give it two coats; when dry, rub it over with a piece of fine sand-paper; it will then be ready for gilding.

(*b*) Brush off the dust, then take a sponge or soft flannel and damp it in spirits of wine, or turpentine, and clean off all dirt and grease. Afterwards apply a coat of thin patent knotting, or use some clean shellac dissolved in methylated spirits. Apply it thin with a camel-hair brush. This will dry in about ½ hour and be quite ready for laying on the gold size, and applying the gold leaf in the usual way.

(*c*) The tools required for the job

are the following : a pint basin with a lip, two moderate sponges, and two small finger sponges, three fitches, one flat, ¼ in. wide, one round ¼ in., and one ⅜ in. or ½ in., round. We will count these three one set, for sizing. You will want another set for whiting, another for claying, one fitch for skewing, one small sash tool for washing off, and one about 1 in. diameter for duster ; a gilders' cushion, a gilders' tip, a camel-hair dabber, a gilders' knife, some fat pipe-clay, some prepared whiting, some plumbago, oil gold size, crystal size, or parchment cuttings to make some, two agate burnishers, one round, about the diameter of a goose quill, and one oval, larger, or about double the above on the broad part, and some composition made of glue, whiting, and linseed-oil. The picture taken from the frame, dust well, and proceed to wash off with clean water, not letting your brush hold too much, to make your work too wet. When washed off let stand by for some time to get dry and steady. Now is your time to make all ornamental work good, or repairs.

To work the compo you will need two pieces of brass wire, one about ¼ in. and one about ⅛ in. full, bent in the shape of an *ʃ*, the ends being flattened to form a kind of trowel in miniature, such as used by artists in clay modelling. Make your compo warm, and work it well, that it may not work lumpy. Having some hot glue, dab some upon the sore place, press your compo upon it ; in a few minutes you may proceed to shape it to correspond to the rest of pattern. Having made all things ship-shape, that which is to be matt, i.e. the bottom of design, is to be laid down with gold size very sparingly, and after that has been gilded, if the prominent parts or that which is in relief is to be burnished, is to be sized and clayed ; then, after being allowed to dry, give another coat of weak size ; this is allowed to dry. When you are about to lay the gold on, wet the surface with clean water.

Oil gold size will take 2–5 hours before it will be fit to receive the gold, and will depend, in a great measure, upon the weather. This oil gold size is composed of prepared linseed-oil, very finely ground litharge, and stone ochre. The cushion-knife and tip can be dispensed with, although these and the dabber are all held in the hands when laying on the gold by the professional. The cushion is a board about the dimensions of a half-sheet of note-paper, the back half of which is walled around with a piece of parchment about 2½ in. high ; the floor of the cushion is wash-leather, as it is usually called, prepared with red chalk ; on the under side is a loop to take the thumb of the left hand, the hooded or walled part projecting over back of the hand, the fingers being curled. The tip is placed between the second and third finger, and the knife between the little finger and next, and the dabber between the forefinger and thumb. He takes a book of gold and shakes out three or four leaves into the hood—pell-mell as it would seem to the uninitiated, places the book down in a safe place, takes the knife and picks up one of the leaves and tosses it about, gives it a puff of air from his lips, and there it is spread out upon the cushion without a wrinkle in it. He then proceeds to carve it up into the shape or size pieces that he sees most convenient to cover his job. He then returns the knife to its proper place, and takes the tip, which is some long badger-hair between some card for a handle. He whisks the tip over the hair upon his head or down his whiskers, and applies it to a piece of the leaf gold ; it instantly picks it up like a magnet. By these means he conveys and deposits the gold where required, replaces the tip, and takes the dabber and dabs it down. Some will dab with the dabber between the little finger and next upon the right hand with the dabbing part outside, and will pick up and dab and cover a frame in a few seconds.

After covering (see that it is all covered), let stand for an hour or two, and skew off. That is done by the skewing-fitch ; the tool is held between the thumb and forefinger of right hand, and pressed lightly down upon the gold, and a slight skewing or twisting action is given to it, and the fine gold or pounce liberated by the action is skewed by the same action into the interstices and angles of the pattern that the dabber could not get at. Continue this action with the powder under your brush, until you have gone around your frame; then skew your gold powder off on to a highly glazed piece of paper and preserve.

When you commence gilding, the best plan is to spread a sheet of manilla paper under your work—this is a very highly glazed paper of a whitey-brown hue, and very tough; the parts to be burnished should have at least two coats of size and whiting and of clay before gold is laid on. Now for the dead and burnished work. Having washed and repaired mitres, etc., and set aside to steady or dry, have some No. 1 glass-paper and rub down with finger or cork rubber. Give one coat of parchment size and whiting; the size must not be too thick or thin, so that it will not congeal at the ordinary temperature of the room or atmosphere. But the test of the thumb and finger is the best criterion to go by; if too thick, your work will peel off when placed in a warm room, or on a hot summer day. If new work, a coat of weak size first, next whiting and size; let dry and rub down. A second coat, dry and rub down, then a coat of clay, then rub down and go over with weak size, and set by to dry. When dry, see that there are no cracks or chance of its peeling off. Then go over with clean water and soft brush slightly damp, lay the gold on immediately after, and dab down. Let stand by to dry. The flat remaining dead, the hollow or bead may be burnished. The burnishers here mentioned are curved like a horn so that you can get into a hollow, a quirk, or over a bead. When completed so far, you may either size or varnish.

It is usual to size matt and ornamented work, and dead upon mouldings. It is a great protection against dust. If not sized, it would soon be smothered in dust, and no dusting or washing would remove it or improve it. Now for sizing: Take a clove of garlic about as thick as a quill, and finely grind it up with a little water. Mix with a couple of table-spoonfuls, let settle and filter. Dissolve size in it and apply. This will lay the rough surface and is said to protect it from that nuisance, fly-soils; but if you would like to varnish that, you may remove the fly-soils with impunity. Take ½ oz. gum-sandarach to ½ pint good spirits of wine, and in another small phial (about 1 oz.) put one pennyworth of saffron. When the former is dissolved and settled clear, pour off, and add some few drops of saffron until of the desired colour; go over the gold with a coat of very weak size, and, when dry, varnish and turn upside-down to dry free from dust. To make the oil gold size—take, say, 1 lb. white-lead and red-lead, mix with ½ pint good raw linseed-oil, add about a gill of boiling water to it; when well mixed up let stand for a day, then add another ½ pint oil and well stir up twice a day (morning and night), and in a few days you will have a beautifully clear fat oil, almost colourless; this must be mixed or ground up with stone ochre and litharge, not as a paint but as a stain, and to render it siccative; this may, when prepared, be kept some considerable time, without drying, in a jar or gallipot, if covered with a piece of paper, dressing the top with oil, but it will dry in a very little time when put on very thin, as for gilding, subject to the state of the weather. It may be ready in 1 hour, and may not be fit in 5 hours. Deep, extra deep, gold is used for the purpose. If you prepare your own whiting, it must be well washed, and remain to allow the coarse to settle a few seconds, and then decanted into another jar to settle; finally, make a tray of a square of blotting-paper, pinch up the corners, and put upon a Bath-brick; pour the water off as far as you can, and the thick into the tray. The brick and paper will soon absorb the water, and your whiting, after the paper covers are taken off, will be free from grit, and may be placed in a jar or bottle fit for use. Your plumbago must be served the same, and your clay, and about 2 per cent. plumbago is mixed and washed with your clay, after being washed separate, and your clay is fit for use. By the Bath-brick the liquor is absorbed very readily, and preparations of this kind, and precipitates, filters, etc., reduced to a minimum of trouble. Your sponges you will find use for in case of swamping.

Reviver for Gilded Frames.—Take 1 oz. of chloride of potash or soda and mix it well into 3 oz. of white of egg. Go over the gilded surface with this and a very good result will be obtained.

Plaster of Paris.—This needs 3 or 4 coats of boiled linseed-oil laid on at intervals of 24 hours, followed by a water size containing finely ground yellow ochre for delicate work, or a coat of japanners' size and yellow ochre for coarser work; the gold size and leaf follow when this is dry.

Pottery. — An air-tight kiln is required, which must be lime-washed every time it is used. On a small scale a retort would do well, made of Stourbridge clay, and fixed in brickwork, with access for drawing trials, bits of pitcher with a little gold on, drawn with tongs. Take ¼ oz. brown gold, ¼ oz. quicksilver, 10 gr. tin, 10 gr. white-lead, well pound together in Wedgwood mortar and pestle. Then grind on glass slab and muller, with a few drops of water, for several hours; add a drop of water as it dries, then repeat in turpentine, leaving it about the consistency of cream. It is then ready for use, or if kept for a day or two it will work better; it is laid on with a camel-hair pencil. Thin it with turpentine, as it soon dries, and should be kept covered when not in use. A little fat oil is added to make it work better. To make fat oil, evaporate turpentine to the consistency of treacle.

Signs or Fascia Lettering.—The following method is adapted for working in the open air, when the ordinary process with the cushion is rendered difficult if there is much wind to blow the gold leaf about. Take a sheet of tissue paper and rub it over on one side only with a piece of white wax. This should be rubbed rather briskly over the surface of the tissue paper, placed on something flat, so that the wax is spread evenly throughout. The paper which has thus been rubbed will possess a certain sticky quality, scarcely perceptible to the touch, but sufficient to cause the gold leaf to adhere to it.

After a whole sheet of paper has been waxed as described, it should be cut into squares a little larger than the leaves of the book of gold. The gold leaf book must be opened and the waxed side of the tissue paper gently pressed upon the gold-leaf with the hand. On removing the paper the gold leaf will be found attached to it. The gold leaf being thus secured upon the waxed paper, is ready for use. It is evident that the difficulty experienced through the thinness of the gold is by this means to a great extent overcome. The tissue paper may be used over and over again.

It is supposed that the letters to be gilded have been written in the most suitable material, and that they are ready to receive the gold leaf. Take up the tissue paper and place it with the gilded side to the letters, and having rubbed the back lightly with the hand, the gold will come off the paper and adhere firmly to the mordant with which the lettering has been written. By this method very little gold is wasted, as the tissue paper being semi-transparent, the gold leaf shows through it, and the operator can see where any portion of the gold adheres to the paper, and can accordingly place it on such portions of the work as it will best fit without an undue number of joinings, though by this process, if the gold leaf is good, not the slightest trace of joining is discernible. The gold leaf should be gently dabbed over with a pad of cotton-wool, which will smooth the surface of the gilt, and remove all superfluous pieces of gold leaf.

As a newly-painted surface is sticky, if the gold leaf were to be applied to it, it would adhere to parts of the ground colour where the mordant had not touched, and where the gold was not required. It is needful, therefore, before the letters or parts to be gilded are marked out, that the newly-painted surface should be dabbed over lightly with dry whiting; but care should be taken that the loose particles are dusted off by the gentle application of a silk handkerchief. If the ground is dark, this pouncing will so far lighten it, that the gilder will be able to distinguish any lines he may make with size, as the size will restore the ground to its original colour. But if the ground is light, the pouncing will not have this effect, and it becomes necessary to mix some kind of colour with the size to enable the gilder to make certain that he has thoroughly covered the portion to be gilded.

For pouncing, put some powdered whiting in a small linen bag, tie it up tightly, and gently dab it over the parts to be pounced. The whiting is removed from the ground after the gold leaf is applied, by means of a damp chamois leather. The mordants for gilding are of different kinds. Picture-frame gilders generally use gilders' size, made of fat oil, in which yellow ochre has been ground. This is a good material for the sign-writer, but it is too thick for general adoption, especially in cold weather, when it is unmanageable with the sable pencil. In hot weather, however, it is not so thick, and may often be used with advantage. The gold leaf must not be applied to this size for at least 24 hours after its application, and it will remain tacky for 2–3 days. When the gilding has to be finished more rapidly, japanners' gold size is generally employed. The gold leaf may be laid on this in about ½ hour after its application, as it dries very rapidly.

Sometimes the gilder is compelled to prepare his work and put on the gold leaf a few minutes afterwards; in this case, gold size alone is used. But if an interval of a few hours is no object, it is customary to add oil varnish to the gold size, regulating the quantity according to the time at disposal. Linseed-oil should not be mixed with gold size to retard its drying properties, because it is apt not only to destroy the adhesiveness of the size, but to sweat through and discolour the metallic leaf. A few drops of boiled oil may be added to the size occasionally, but as a general rule varnish will be found preferable to the oils.

Textiles.—The surfaces of textile materials require a grounding of water size (*see* CARDS), which may be weak glue for coarse fabrics.

Water Gilding, will not bear being wetted, and is only fit for work to be always kept within doors. For this gilding the wood is first covered with 4 or 5 coats of whiting and size; and that the gilding should be perfect, it is necessary that there should be a sufficient body of whiting. When these are dry, they are laid over with a coat of gold size, made of Armenian bole, a little wax, and some parchment size. When the size is dry, a portion of the surface is wetted plentifully with clear water and a soft brush, and a leaf of gold is applied, so as almost to float on the water, when it instantly settles down and adheres to the size. Great care must be taken not to suffer any of the water to come over the gold, or a stain will be produced. When the whole is covered with gold leaf, the effect is what is called matt, or dead gold, and is the natural colour of gold not burnished. Such parts as are required to be burnished are rubbed over with an agate burnishing tool. Ornaments executed partly matt and partly burnished, have a very rich effect, which is seen in most picture frames.

As already stated burnished gilding

cannot be cleaned with water, though oil gold may; but the matt portion of water gilding is so like oil gold, as not to be distinguished by an inexperienced eye; and it may be very desirable to know, in that case, by which of the two processes it has been executed, with a view to cleaning it when soiled by flies or otherwise. This may be ascertained by observing in some crack or crevice whether the gold is laid on a coat of whiting; and if there is no other method, a small scratch with a knife may be made in some unimportant part to ascertain the fact. On account of the impossibility of washing water gilding without injury, it is necessary to take great care to protect it.

Frames executed in water gilding are sometimes required to be regilt; this cannot be done without taking off the whole of the whiting, and commencing the process again, which is expensive. When this is done the frames may be either regilt in the water or in the oil manner; and as the latter is much the cheaper, it is sometimes preferred, although it cannot be burnished.

Wood (Oil Gilding).—The gilding on wood, called oil gold, cannot be burnished, and is always of the natural colour of unwrought gold. It has the advantage that it may be washed and cleaned with water, which burnished gold never can. It is often used for picture frames, parts of furniture, and mouldings of apartments; as it stands the weather, it is also employed for outdoor work. The surface to be gilded should first of all be rubbed smooth, if stone with pumice, if wood with Dutch rushes, if a very bright level effect is desired. After this it should have a priming of glue size, and two coats of oil paint and one of flatting. To enrich the colour of the gold, these last may be laid down in red or yellow. White, however, is usually preferred, as the darker colour renders any imperfection in the gold-sizing more difficult to detect. When the last coat of paint is thoroughly dry, rub it over with wash leather, to render it smooth and free from dust or grit. If there are any patterns or figures which are to be left ungilded, they should be lightly pounced over with white to prevent the gold leaf adhering to them.

Another way is to paint the pattern with white of egg diluted with water. If any gold sticks to this, it can be easily washed or wiped off with a moistened handkerchief. When all is ready for sizing, strain sufficient size through muslin, and put some out on the palette, adding to it enough ochre or vermilion, mixed with oil alone, to colour. Then with a stiff hog-hair tool commence painting it on the surface, taking care to lay it on smoothly, and not too thick. If put on too thickly it runs, and leaves wrinkles in the gilding. Size always from left to right, beginning at the top of the surface, and working downwards. Move the brush lightly and firmly, mapping out the surface to be sized into several squares, and finishing and cross hatching each before proceeding onwards. If there are patterns to be left ungilded, carefully trace round their outline first with a sable pencil, and then fill in the interstices. When the whole surface is covered with size, give it a thorough inspection to make sure there is no faulty portion, and if there is, delicately touch in the size with a small pencil. When very perfect gilding is required, it should be sized twice, the first coat being allowed to dry thoroughly before the second is applied.

In carved work, be careful to dip the brush down into the hollows of the carving. It is a good plan to size over night, so as to gild in the morning. But all size does not dry alike, sometimes taking 12 to 24 or 30 hours before it is ready for the gold leaf; in damp weather or positions, always more than in dry. The readiness of the size can only be ascertained by the touch. If on being touched by the finger the surface daubs or comes off, it is not ready, and must be left; if it feels clammy and sticky, it is sufficiently matured. If too dry it must be sized again.

The books of gold leaf should always be placed before a fire ½ hour previous to use, in order to thoroughly dry the gold and make it more manageable. When all is ready, shake out several leaves upon the gold cushion, and blow them towards the parchment screen. Then carefully raise one leaf with the blade of the knife, and place it on the cushion, gently breathing on it to flatten it out. If it cockles up, work it about with the knife-blade until it lies flat. Then replace the knife in its loop under the cushion, and taking the tip, pass it lightly over your hair, thus acquiring sufficient greasiness to enable the gold to stick to it. Lay the hairy portion of the tip upon the gold leaf, and then raising it, apply it to the sized surface. As in sizing, work from left to right, and be specially careful to let each leaf overlap slightly, so as to avoid gaps and spaces. Lay on whole leaves as far as the space allows, and then proceed to gild the curves and corners which need smaller pieces. Place a leaf flat and smooth on the cushion, and then taking the knife in the right hand, draw the edge easily and evenly along it with a gentle pressure. Divide the leaf into as many pieces as required, and lay on as before. When the ground is complete, give a very careful inspection to make sure there are no portions ungilt, however small, and mend them at once. Next take a pad of cotton wool, and gently dab or press the gold down all over, finally brushing off the superfluous pieces either with cotton wool or the camel-hair brush. It is a good plan to stipple the gold with a large stiff hog-hair tool, quite dry and clean, as this gradually softens and removes the marks of joining and other little imperfections. Finally smooth the gold with a clean piece of wash-leather, and it is completed.

Gilding with Japanner's Size.—With this the same instructions apply, except as to the time necessary to wait between sizing and gilding. If japanners' size is used pure, it will be ready in 20–30 minutes, but better gilding can be made by mixing one-third oil size with two-thirds japanners' size. This will be ready in about 2–4 hours from the time of putting on. When all the gilding is finished, dilute one-third very clean and pure parchment size in two-thirds water, and brush it all over the surface of the gold to enrich and preserve it. If it is necessary to gild in a position much exposed to touch, as the base of a pillar, or string-courses, it is as well to give the gold a coat of mastic varnish thinned with turpentine.

There are various processes which tend to enrich and vary the effect of gilding. Glazings of transparent colour are sometimes applied for the purpose of deadening its lustre. Raw sienna passed thinly over a sheet of gold gives it a leathery appearance. A good effect may be produced by stencilling a small diaper in umber, sienna, or Indian red, over gold, especially if there is foliage or arabesque work upon the gilding, as the small diaper affords an agreeable relief. This is the easiest mode of gilding; any other metallic leaves may be applied in a similar manner.

Plain Wood.—Before gilding plain wood, its absorbent character must be destroyed by the application of a ground colour, which may be japanners' gold size mixed with yellow ochre previously ground very fine in turpentine, or a compound of boiled linseed-oil and a pigment of good body, such as white-lead. The painted ground, when dry, is rubbed down smooth with fine glass-paper, and any required number of coats added and similarly smoothed, when the sizing and gilding follow in the usual manner.

Polished Wood.—In the case of polished wood, the coat of polish serves the purpose of a ground colour, and renders the latter needless. Should the gilding be destined to cover only portions of the surface, the precaution must be taken, before applying it, to rub whiting on the parts not to be gilded, so as to prevent the adhesion of the leaf to the otherwise sticky surface. The sizing and gilding are conducted in the ordinary way.

Zinc Organ Pipes.—Organ pipes should be first coated with mastic varnish, and then oil-gilded in the usual manner.

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GLASS.

(*See also* ENAMELLING, ENGRAVING, GILDING, LEAD GLAZING, AND STAINING.)

THERE is not space, nor is it within the province of this book, to deal with the manufacture of glass and glass goods, but there are a number of works and processes connected with glass that may be described. Glass consists chiefly of silica, this latter substance being a constituent part of many rocks and stones and occurring in a free state as flint, quartz, rock-crystal, agate, etc. Silica combined with various metallic salts become known as silicates, but these alone are not easily fusible, nor have they the qualities required in glass in the best degree. It is a mixture that makes the glass of commerce. Thus a silicate of potash and oxide of lead make flint glass, crystal ware, etc. Silicate of soda and lime, or silicate of potash, soda and lime, make common window glass, English crown and plate glass. Silicate of potash and lime make foreign crown and refractory glass. Silicate of soda, lime, alumina and oxide of iron, form coarse green bottle glass. Many of these ingredients, more or less mixed, are found as natural earths. The silicate of alumina for instance represents most forms of clay. The silicate of lead imparts brilliancy and is of easy fusibility, but excess of lead gives a yellow tint. Silicate of lime gives hardness. Silicate of alumina gives hardness with tendency to crystallise, but the addition of other simple silicates corrects the latter defect. Silicate of iron gives the colour of dark bottle glass. Potash and soda render glass easy of fusion, especially the former. The raw material may be flints, calcined and ground, but sea sand which is quartz is largely used. Ordinary sea sand commonly has iron in it which gives a bad colour to the glass and which might be rectified, but the makers prefer using sand without the iron, this being obtained from several spots on the coast of England, also from as far away as Australia whence it comes as ballast in vessels.

The following extract from a paper read by Mr. Harry Powell will be found interesting as briefly explaining the manipulation of glass.

All table-glass worthy of the name is blown glass. Every vase, wine-glass, or decanter has commenced its career as a white-hot, solid mass of viscous material coiled round the end of a long iron blowing-tube. A well-regulated puff of breath through the tube creates a bubble, and the bubble is the embryonic stage of all table-glass.

The form of the bubble can be readily modified. Glass, so long as it is hot is almost infinitely ductile, and even after it has been partly chilled, its ductility can be restored by re-heating. If the bubble, while still attached to the blowing-iron, is held downwards, it lengthens out into an ellipse; if the blowing-iron is held vertically with the bubble uppermost, the bubble compresses itself into the form of a "scone," and if the scone is pierced in its centre, and the blowing-iron is trundled like the handle of a mop, the scone unfolds itself into a flattened disc. By these simple movements (which are in constant use in the glass factory) the form of the bubble is modified without the use of tools. With the aid of a primitive-looking tool, closely resembling an exaggerated pair of sugar-tongs, and of a stool or chair with two parallel projecting arms, between which the workman sits, and on which he rests and rolls the iron rod to which the glass is attached, every imaginable modification of a spherical form can be developed.

At the present time, owing to a demand for excessive regularity and excessive lightness and thinness, very many of the simple forms of table-glass are blown in moulds. This process of moulding requires comparatively little skill, and the valuable training which the fashioning of simple forms with the tool affords is being lost. If the fashion and demand for so-called "aerial" glass is long continued, the skilled craft of glass-blowing will disappear.

The display of niceties of form depends in no small degrees on the chemical nature of the glass employed. For this purpose the soda-lime glass, which is used in Venice, and the use of which has recently been introduced in England, although it is seldom absolutely white, and often streaky and bubbly, is better adapted than the obtrusively brilliant potash lead glass, from which English table-ware is commonly made.

The surface of vessels may be rendered lustrous by rolling the hot glass on metallic leaf, or iridescent by the deposition of metallic tin, or by the corrosion caused by the chemical action of acid fumes. Gilding and enamel decoration are applied to vessels, when cold, and fixed by heat.

Cutting and engraving are produced by pressing the surface of vessels against the edge of wheels revolving on horizontal spindles. "Cutting" wheels range from 18 in. to 3 in. in diameter, and are made of iron for grinding, stone for smoothing, and wood for polishing. "Engraving" wheels are small, ranging from 1 in. to ⅛ in., and are made of copper.

Annealing. — This consists in putting the glass vessels, as soon as they are formed, and while they are yet hot, into a furnace or an oven, not so hot as to re-melt them, and in which they are suffered to cool gradually. It is found to prevent their breaking easily, particularly on exposure to heat.

Action of Hydrofluoric Acid on Glass.—Glass of various kinds may be said to be all compounds of silica with different metals or metallic salts. All are soluble in hydrofluoric acid so that they might be completely dissolved if the acid was in sufficient volume, but the action with some is slower (or quicker) than others. In consequence of this there is a difference of action with various kinds of glass, depending on the composition. As, in etching, the quantity of acid is small compared to the bulk of glass, it first attacks those silicates which are most soluble, leaving the less soluble to form a matt surface. If the glass is a homogeneous double silicate it will dissolve clear. As a rule, the acid when applied as a liquid on the glass forms a fairly or quite smooth surface, whereas if its fumes only are used it forms a rough matt surface.

Bending Tubes.—If a sudden bend is wanted, heat only a small portion of the tube to a dull red-heat, and bend it with the hand held at the opposite ends. If the bend is to be gradual, heat an inch or two of it in length, previous to bending it. If a gradual bend on the one side, and a sharp one on the other, as in retorts, a little management of the tube in the flame, moving it to the right and left alternately, at the same time that it is turned round, will easily form it of that shape. In bending glass, the part which is to be concave is to be the part most heated. An ordinary atmospheric gas flame is quite sufficient to bend glass by, or that of a spirit lamp.

Care should be taken in bending not to use much pressure as to break the glass, or to hold the tube in such a way that no injury will result to the hands from a break, as serious injury may be caused by the razor-like edges of a broken tube.

Bevelling Edges of Plate Glass.—(*a*) For this subject the reader should be referred to a text book on glass working, but the process may be briefly described here. The first requirement is a horizontal circular table, made to revolve. Face plates are provided to go on the table for rubbing, smoothing and polishing. When the glass is to be bevelled, it is held by a support at the angle required for the bevel, and the edge of the glass is then brought down on to the revolving table. For the first rubbing the face plate is of cast iron, and the cutting material is sand or emery and water. This makes the full bevel, but when it is nearly formed a fine sand or emery should be used. When the bevel is made the cast-iron face plate is removed and a glass one substituted, and flour emery is used to remove all the marks of the previous rubbing. The final polishing is done with a wooden face-plate with rouge as the polishing material.

(*b*) The foregoing briefly describes the process with straight edges and the following relates to bevelling circular plates. In this case the glass plate revolves as well as the grinding disc. The first thing to do is to set the circle of plate glass in a thin bed of plaster of Paris on a circular plate a little larger than itself. This plate must be supported on a rod on which it can revolve. This rod may be made to slide in a bearing on the lathe, being held at the required height by a set screw. The plate is horizontal. The grinding or rubbing disc is set at a suitable angle to make the bevel, this disc being of steel and the cutting material sand and water. The iron plate holding the glass circle is moved up until the glass and the grinding disc just meet, the disc being then set revolving. As the glass is ground away so it is moved up closer until the required bevel is obtained, this leaving about $\frac{1}{16}$ in. thickness unground, bedded in the plaster. When the bevel is formed, the smoothing and polishing is done first with fine emery followed by discs of wood with rouge or putty powder; and, in some cases, wood covered with leather and finally wood covered with felt.

Breaking (*and see* CUTTING).—(*a*) Easy method of breaking glass to any required form. Make a small notch, by means of a file, on the edge of a piece of glass, then make the end of a tobacco pipe, or a rod of iron of about the same size, red-hot in the fire; apply the hot iron to the notch, and draw it slowly along the surface of the glass in any direction you please: a crack will be made in the glass, and will follow the direction of the iron. Round glass bottles and flasks may be cut in the middle by wrapping round them a worsted thread dipped in spirits of turpentine, and setting it on fire when fastened on the glass.

(*b*) In breaking a glass tube, e.g. a combustion-tube, a small scratch is made with a file at the required place. At each side of this scratch, and about 1–2 mm. away from it, a small roll of wet blotting-paper is laid round the tube. The free space between is then heated all round over a Bunsen burner, or better still, over a small blowpipe-flame. A clean and even fracture is thus obtained, exactly between the two rolls, without dropping water on the hot glass. The rolls are made by cutting two strips of filter-paper, sufficiently large to form rolls 1–2 mm. high, and 2–4 cm. wide. The strips are folded once, lengthways, laid on the table, moistened, flattened out, and then wrapped on to the tube, so that the fold lies nearest the file-scratch, and fold lies accurately upon fold in the successive layers. The thickness of the rolls, and their distance apart, has, of course, to be varied, according to the diameter of the tubes. Equally good results are obtained with the thinnest test-tubes, the thickest combustion-tubes, beakers, flasks, and glass bell-jars. In those cases, where the sides are slanting, as, for instance, with funnels, an obvious alteration in the construction of the paper rolls need only be carried out. ('Analyst.')

Cleaning.—Grease may be dissolved from glass by means of carbonate of soda, carbonate of potash, or, better still, by caustic soda, made thus: 10 parts of carbonate of soda are dissolved in 100 parts of water (10 oz. to 100 oz.), and heated to ebullition in a clean untinned iron vessel, 8 parts of good quicklime are meanwhile slaked in a covered basin, and the resulting hydrate of lime is added, little by little, to the boiling solution of carbonate, with frequent stirring. This will give a very strong caustic solution, and should be used with care. Keep your hands out of the solution, and dip the glass in by means of the pliers, keeping them moving while in the solution. When the grease is dissolved or loosened, scrub with a brush, well rinse in water, and dry.

Coating on Metals.—The following method has been suggested for coating metallic surfaces with glass: Take about 125 parts (by weight) of ordinary flint-glass fragments, 20 of soda carbonate, and 12 of boracic acid, and melt. Pour the fused mass out on some cold surface, as of stone or metal, and pulverise when cooled off. Make a mixture of this powder with soda silicate (water-glass) of 50° B. With this coat the metal to be glazed, and heat in a muffle or other furnace until it has fused. This coating is said to adhere very firmly to steel or iron. *And see* ENAMELS.

Coloured.—(1) It is supposed that any one of certain metals, if its condition of oxidation or its proportion be varied, will, in combination with glass, produce the several effects of colour into which white light can be decomposed. Thus, copper, when suitably treated, will produce the effects of blue, green, and red. Metals enter into combination with glass in various ways. The effect of avanturine-glass is due to the suspension in the body of the glass of minute particles of metallic copper. When gold oxide is used as a colouring agent, it often happens that some oxide is reduced to the metallic state, and the result is a glass which, when viewed by reflected light, appears to be of a dull opaque red colour, but by transmitted light, yields a beautiful opaline blue. Opacity is probably due to an insoluble excess of metallic oxide held in suspension in the glass. White opacity is obtained by the use of arsenic trioxide, tin dioxide, lime phosphate, powdered talc, or cryolite. The effect of blackness is obtained by the oxides of iridium, manganese, cobalt, copper, or iron in excess.

Gold to be used in colouring glass is first dissolved in aqua regia; the solution, together with oxides of antimony and tin, is added to the ordinary ingredients of flint-glass. The ruby colour is in a great measure due to the reducing action exercised upon the gold salt by the stannous oxide. Ruby-glass is usually gathered from the crucible in the form of lumps, weighing ½-1 lb. As it is gathered from the crucible, it is perfectly colourless, and only acquires its colour after it has been chilled and reheated in the annealing-kiln. The ruby lumps, after having been annealed, are reheated as they are required, and used for casing the flint-glass. Articles are never made of solid ruby-glass, partly on account of its cost, but chiefly because the colour is so powerful that an almost invisible film imparts a rich colour to the article upon which it is spread.

The red colour of copper ruby-glass is due to cuprous oxide, and all substances liable to part with oxygen, and to convert the cuprous into cupric oxide, must be avoided in its preparation. In addition to avoiding oxidising agents, such as red-lead and manganese oxide, it is necessary to add reducing agents, to counteract such effects of oxidation as are unavoidable. Stannous oxide and iron scales or filings are for this purpose mixed with the raw materials. The ruby colour produced is intense, and can only be used as a casing for colourless glass. The ruby-glass, when gathered from the crucible, is of a pale greenish-blue colour, and, like the gold ruby, requires to be partially cooled and again heated before the red colour appears. If reheating is carried too far, the red is replaced by a dull brown tint. If copper and iron scales be added in great excess, an opaque red mass is obtained.

Cupric and cuprous oxides, when used without reducing agents, produce peacock-blue or green; the result apparently depends on the quantity rather than on the state of oxidation of the copper. A very minute proportion of cupric oxide will give a distinctly blue tint. Ferric oxide (Fe_2O_3), in the presence of manganese dioxide, which parts with its oxygen, and thereby tends to maintain the oxidation of the iron, produces a rich yellow. Ferrous oxide (FeO) gives a dull green; it is obtained either by the oxidation of metallic iron in the crucible, or by the reduction of ferric oxide. Manganese dioxide by itself and in large quantity gives violet. If the mixture be heated too long, the oxygen is driven off, and the glass is rendered colourless. A red is obtained by a mixture of manganese dioxide and ferric oxide. A minute trace of cobalt oxide imparts a deep purple-blue. Nickel oxide produces a deep red-brown. The oxides of chromium are very slightly soluble in glass; a minute quantity gives an emerald-green or yellow colour; any excess remains in the form of glistening crystals in the body of the glass, and tends to its disintegration. Antimony trioxide imparts a faint yellow tint; excess tends to produce opacity. Oxide of cadmium gives a pale yellow. Uranic sesquioxide produces a bright yellow, but its peculiar property of fluorescence, already referred to, gives to the glass, when viewed by transmitted light, a bluish-green effect. Silver oxide, in common with cuprous oxide, possesses the power of staining glass, when applied as a pigment to its surface, and heated. This is a more convenient way of obtaining the yellow colour which silver oxide gives to glass, as, when mixed with the raw materials of glass, and placed in a crucible, it is only with the greatest difficulty that the oxide can be prevented from becoming reduced. If reduced, metallic silver sinks to the bottom of the crucible, and the glass remains colourless.

The metallic oxides necessary for the production of coloured glass, are introduced into the crucibles with the raw materials. Sheets or circles may be entirely gathered from one crucible, or from more than one, so as to produce a glass composed of two differently coloured layers. Copper-ruby and gold-ruby glasses are always treated in this manner, on account of the great strength of the colours. Ruby is often cased upon blue, green, and yellow, as well as upon white; and blue upon white and green. These cased glasses are particularly useful for representing heraldry, as the casing can be removed by abrasion, or by hydrofluoric acid, and the subjacent ground discovered. Splashed or sprinkled glass is produced by rolling the gathered mass of molten glass in small fragments of differently-coloured glasses; the fragments become incorporated in the molten glass, and expand together with it.

Only 2 transparent glass stains are at present known: a yellow stain, produced by silver oxide; and a ruby, by cuprous oxide, the latter being very rarely used. A stain may be roughly described as a transparent effect of colour obtained by applying certain metallic oxides to the surface of the glass, in the same manner as pigments are applied to canvas or paper, and by subjecting the glass to heat. The stain should be incorporated in the glass, and be as durable as the glass itself. For yellow, either oxide or nitrate of silver is used; the latter is preferable by reason of its solubility and easy manipulation. In either case it is necessary to employ some finely divided infusible medium, moistened with water or tar-oil. The media generally used are iron peroxide and kaolin. (Powell.)

(2) The articles made at Venice of black glass are distinguished above all other productions of that sort by their deep black colour, and on this account meet with much favour. Dr. Kayser, of Nürnberg, investigated the composition of a frit from a Venetian glass factory, and also some black glass wares made there. The following were the results:—

(*a*) The glass frit had the ordinary appearance of a frit, and showed under the microscope isolated small pieces of black glass. In hot water, 29·7 per cent. were soluble, consisting of alkalies and salts of magnesia. These were in combination with carbonic acid, chlorine, and sulphuric acid.

The frit contained—

Silicic acid	55·57
Clay	2·08
Iron oxide	1·25
Manganese protoxide	1·80
Lime carbonate	8·88
Magnesia sulphate	3·95
Soda sulphate	3·55
Potash chloride	0·55
Soda chloride	10·66
Soda carbonate	11·85
	100·14

(*b*) A rod of black glass, such as is used for the manufacture of glass pearls, contained:—

Silicic acid	69·69
Clay	1·94
Iron oxide	2·43
Manganese protoxide	11·39
Lime	7·53
Magnesia	1·26
Soda	5·41
	99·65

From the analyses it is probable that the black colour of the glass is caused by the large proportion of manganese in it. To certify this conclusion, a mixture of sand, soda, and powdered manganese ore (to the extent of 15 per cent.) was melted in a Perrot's glass furnace. The glass substance obtained was deep black while in very thin layers, and dark violet when drawn out in very thin threads, as well as in thin splints. Hence, in point of colour, it was exactly like the Venetian black glass. ('Gewerbehalle.')

(3) Glass may be stained by painting its surface with a fusible coloured glass ground to a fine powder and mixed up with gum-water or turpentine, and, after drying, then heating the painted glass in a furnace until the coating fuses. Collodion, shellac, or spirit-copal varnishes, coloured with one of the coal-tar dyes, can in some cases be advantageously resorted to as a coloured wash for white glass.

(4) The pigments commonly employed for decorating glass and porcelain have hitherto been prepared either by melting the metallic salt, which is generally the nitrate, in rosin (colophonium), or by decomposing soluble rosin soaps with the solutions of these salts, whereby an insoluble resinate is formed which is first dried and then dissolved, just as that formed by fusion is in oil of turpentine, lavender, nitro-benzol, or some similar solvent. Both these methods of preparation have their disadvantages, the principal being that a considerable quantity of the metallic salt remains undissolved, and when the resinous mass is dissolved, it is precipitated and lost, or at best is only recovered by a tedious operation. With the help of carbolic acid, these pigments can be prepared without difficulty, and without any insoluble metallic compounds separating, worth mentioning.

Bismuth.—2½ dr. metallic bismuth are dissolved in aqua regia, and evaporated in a porcelain dish to a thin syrup. When cold, 12½ dr. carbolic acid liquefied by gently warming in hot water are added. It is left standing a few hours, for, if warmed and stirred at once, an energetic reaction takes place, with violent foaming. At the end of this time, it is well stirred with a glass rod and heated awhile in a steam bath, when there will be an evolution of hydrochloric acid vapours. It is taken out of the steam bath as soon as a drop removed on a glass rod will dissolve clear in nitro-benzol. When this point is reached, the mass is dissolved in nitro-benzol or a mixture of nitro-benzol and oil of spike, when the preparation will be ready to use.

Tin.—2½ dr. pure tin are dissolved in aqua regia, and the solution is evaporated to a thin syrup, then mixed with 12½ dr. carbolic acid in the manner above described. The remainder of the operation is the same as for bismuth.

Uranium.—3¾ dr. uranium nitrate are mixed with 10 dr. hydrochloric acid and dissolved. This solution is also mixed with 12½ dr. carbolic acid, as before, and treated as already described.

Iron.—3¾ dr. iron perchloride are dissolved in pure hydrochloric acid, and any excess is removed by evaporation, so that the solution when cold will have the consistence of a thin syrup. To this are added 12½ dr. carbolic acid; and it is then treated as described under bismuth.

Manganese pigment can be made from manganese chloride, and nickel and cobalt pigments from their chlorides, in precisely the same manner as that of iron is made from its chloride. The finished preparation can be diluted to any desired extent, as the concentration of the original preparation leaves plenty of play for the dilution. The different pigments above described may be mixed with each other to form all kinds of combinations. (Dr. R. Kayser, 'Deut. Ind. Zeit.')

Imitation Gems.—The property of glass to display a variety of tints by the addition of metallic oxides, is made use of for the production of artificial gems. The percentage composition of the base used is SiO_2, 38·10; K_2O, 7·90; PbO, 53·0; Al_2O_3, Fe_2O_3, 1·00. (Powell.)

Weiskopf gives the following formulæ for the frit used in Bohemia for making imitations of some of the precious stones:—

Imitation Agates.—10 lb. quartz, 17 lb. red-lead, 3·2 lb. potash, 2·2 lb. borax, and 0·1 lb. arsenic. The quantity of chloride of gold added is equal to that obtained from 0·4 of a ducat.

Agate Glass.—10 lb. broken glass is melted, and to it are added 0·15 lb. copper oxide, 0·15 lb. each of the oxides of chromium and of manganese, 0·02 lb. each of oxide of cobalt and nitrate of silver, 0·01 lb. oxide of uranium, 0·4 lb. red argols, 0·3 lb. bone meal. Each oxide is added alone and at intervals of 10 minutes. After heating the mixture for an hour, 0·3 or 0·4 lb. of fine soot is put in.

Red Marble.—80 lb. sand, 40 lb. potash, 10 lb. lime, 2 lb. table-salt, 1 lb. saltpetre, and 0·1 lb. arsenic. The mixture is melted, and then 25 lb. copper suboxide and 1 lb. saltpetre are mixed in.

Artificial turquoises are made in Paris and Vienna that cannot be distinguished by external appearances from the natural product, and when artistically made can only be distinguished by means of the file, being usually softer. They are made from alumina phosphate and copper phosphate mixed together and subjected to hydraulic pressure. Even in chemical composition they resemble the natural mineral which is a hydrated alumina phosphate with 2 per cent. of copper oxide. ('Diamant.')

The primary materials from which the different kinds of artificial stones are made on the Continent is as follows:—

Pure pulverized quartz	45·7
Pure dry soda carbonate	22·8
Calcined borax	7·6
Saltpetre	3·4
Pure red lead (minium)	11·8

These substances are thoroughly mixed together, introduced into a Hessian crucible, and heated to vivid redness in a charaoal fire. When the mixture has been thoroughly melted, the product is a transparent crystal glass of very great brilliancy. In order to imitate the various precious stones, certain oxides or carbonates are added to the above ingredients in the following proportions by weight:—

For sapphire, add	0·106	cobalt carbonate.
,, emerald ,,	0·530	iron oxide.
,, amethyst ,,	0·265	manganese carbonate.
,, topaz ,,	1·590	uranium oxide.

Artificial Rubies.—According to Denault, a magnificent description of artificial ruby can be obtained in the following manner: Of the mixture given above to produce the white transparent basis of all these stones, 31 parts by weight are taken, which, finely pulverised, are intimately mixed with 2·30 parts antimony glass and 0·05 purple of Cassius. On cooling this mixture, after being well melted, it sometimes gives a transparent mass, and at others an opaque product. When transparent, it is a brilliant imitation of the topaz; when opaque it forms a splendid imitation ruby by melting 1 part of it with 8 of the primary material (1st formula given above). The product when taken from the crucible is in the form of a brilliant yellow crystal, but before the blow-pipe it is transformed into a vivid red crystal, having exactly the tint of the oriental ruby. (Elsner.)

Crystalline or Chipped.—Few trade secrets have been kept so well from the knowledge of the general public as the process of producing the above-mentioned species of decorative glass. It is said to be the invention of a French engineer who called it "vierre gievre," or frozen glass. In the United States, where its manufacture has been brought to a greater state of perfection than in any other country, it is known under the more common names of chipped or crystalline glass, and the operation of manufacture "glass chipping." It has a remarkable appearance, being covered with fern-like figures no two of which exactly resemble each other, differing in both shape and form. To those unacquainted with the method of producing this glass—and there are very few that have any conception of how it is made—the process of manufacturing is very puzzling.

This method of ornamenting glass is so simple that most people, when they have it first explained to them, will hardly believe that such simple means can produce such marvellous results. It is done by covering glass with glue, which adheres to the glass, and when the glue dries it shrinks and draws with it pieces of the glass or chip of glass.

The first necessity in carrying out this process is to have the glass which is to be ornamented ground either by means of the sand-blast or by the more troublesome means of grinding by hand. This is done by rubbing a stone with a flat side over the glass till it has lost its polish and become translucent. A thin layer of emery, kept wet with water, will facilitate the grinding, which should be as coarse as possible, and for which reason grinding done by the sand-blast is preferable.

After the glass has been ground it should be kept scrupulously clean. Great care should be exercised that the surface is not touched by the hands. Any trace of grease is very apt to make the results uncertain. If the glass has, however, become contaminated, it may be cleaned with very strong ammonia, although glass which it has been necessary to clean is apt to be rather unreliable.

When everything is ready, the glass is placed in a room where it is intended to carry on the process, accurately levelled, and flowed with a solution made as follows:—

Good glue is placed in sufficient water to cover it, and allowed to soak for 24 hours. If the water is absorbed during the soaking, more may be added. It is then liquefied over a water-bath, and is then ready to use.

In practice it makes considerable difference which kind of glue is used. By repeated experiments it has been found that Irish glue is the best for the purpose.

A wide brush is dipped in the glue and applied to the glass. The coating should be a thick one, otherwise it will not be strong enough to do the work required. When the plates are coated, they may be placed in racks, and the temperature of the room raised to 95° or 100° F. They are permitted to remain at this temperature till they are perfectly dry, which will be in 10 to 20 hours.

It is at this stage that the uncertain character of glue shows itself. Under certain circumstances the glue will begin to crack and rise of itself without any more manipulations; but most generally it will require to have a stream of cold air suddenly strike it. If the plate is perfectly dry at this period, and of sufficient thickness, the top surface of the glass will be torn off with a noise resembling the crack of a toy pistol. Sometimes the pieces of glue will leap 2 or 3 in. in the air, and may even fly into the eyes and injure them. To guard against this it is customary for the workmen to wear a pair of spectacles fitted with plain glass. The glue will come off sometimes at the least expected times, notably if the plate with dried glue is being carried from one room to another. Plates which have shown a decided disinclination to chip have manifested a remarkable and unexpected activity, and have jumped into the face of the person carrying them in such a manner as to cause him to drop them.

The strength of the glue is very extraordinary. If the glass has been coated on the hollow or belly side of the glass, the slight leverage thus obtained is almost sure to break it, especially if the glass be single strength. Even plate glass is not unfrequently broken. It might be a rather interesting mathematical calculation to find out the force necessary to separate the surface of glass in this manner on a piece, say, 48 in. by 48 in.

The result of the operation described may be either a design resembling ferns of various shapes and sizes, or it may be a circular design, exhibiting narrow, feathery appearances; or, if unsuitable glue has been used, it may be of a nondescript appearance.

If, after the glue has been applied, but before it has become any more than set, a piece of stout paper is pressed over it and it is allowed to dry in this way, the glass will have less the appearance of feathers, but will be much coarser, and larger pieces will be removed.

The circular design mentioned occurs under the same circumstances as the other, with the exception that it generally is made during cold weather. Sometimes several weeks may run along and nothing but this formation be made.

Some very elegant designs may be produced by submitting the glass once more to the same operation, covering it as before and allowing the glue to chip. This is known by the name of double chip. If the glass was covered with the small circles in the first place, the second time it will have an appearance very much resembling shells, and for this reason this has been called shell chip.

If, instead of using ordinary glass, coloured glass is employed, pretty and original effects may be obtained. The glass may be either coloured clear through, or it may have only a thin coating on one side. In the latter case, in some places the entire layer of coloured glass will be removed, and in other places only a very little, and will, therefore, give all the gradations between those two extremes.

Glass which has been treated in this way may be silvered and gilded, and thereby be made still more remarkable in appearance.

Extremely elegant effects may be obtained by what is known as "chipping to a line." The design is ground in the glass by the ordinary sand-blast process. After the glass has passed through the machine, the protective coating (wax is generally used) is not removed, but is left on to keep the glue off those parts which are not intended to chip. The glue is then applied in a thick layer to the ground portion, and the process is carried on as usual.

Cutting.—(1) Annealed glass vessels may be subjected to a variety of processes after they have become cold. The mark of fracture left at the base of a blown-glass vessel by the working-iron, is removed by pressing it upon the edge of a swiftly-revolving stone wheel. After the inequality is removed, the roughness is polished away by substituting a wooden wheel for the stone one. Cutting and engraving are modified forms of the same process. The difference of effect lies in the greater depth of incision produced in cutting. In either process, lathes are used, in which the glass is pressed against the cutting tools; these are wheels revolving rapidly in a perpendicular plane. In cutting, the lathes are driven by steam, and the cutting wheels are of considerable dimensions. The actual cutting is performed by iron wheels supplied from hoppers with sand and water. The incisions produced by iron wheels are smoothed by stone wheels supplied with water, and are polished by wooden wheels supplied with water and emery-powder, putty-powder, pumice, or rouge. For engraving, the lathes are usually worked by foot-treadles, and the wheels are of copper, and in some cases do not measure more than ⅛ in. in diameter. In engraving, it is customary to leave the pattern rough and the ground clear; this arrangement, however, may be reversed, by polishing the pattern with leaden wheels supplied with oil and rouge, and by previously roughening the ground. (Powell.)

(2) Glass can be cut under water, with great ease, to almost any shape, by simply using a pair of shears or strong scissors. In order to ensure success, 2 points must be attended to —first and most important, the glass must be kept quite level in the water while the scissors are applied; and secondly, to avoid risk, it is better to begin the cutting by taking off small pieces at the corners and along the edges, and so reduce the shape gradually to that required, as if any attempt is made to cut the glass all at once to the shape, as we should cut a piece of cardboard, it will most likely break just where it is not wanted. Some kinds of glass cut much better than others, the softer glasses being the best for this purpose. The scissors need not be at all sharp, as their action does not appear to depend on the state of the edge presented to the glass. When the operation goes on well, the glass breaks away from the scissors in small pieces in a straight line with the blades. This method of cutting glass has often been of service

when a diamond has not been at hand, for cutting ovals and segments, and though the edges are not so smooth as might be desired for some purposes, yet it will answer in a great many cases.

(3) To cut glass jars, fill the jar with lard-oil to where you want to cut the jar; then heat an iron rod or bar to red heat, immerse it in the oil; the unequal expansion will crack the jar all round at the surface of the oil, and you can lift off the top part.

(4) The following is said to be an easy way of cutting glass bottles, carboys, etc., into hand-lights. Pass 5 or 6 strands of coarse packing twine round the bottle on each side of where you want it divided, so as to form a groove about ⅛ in. wide; in this groove pass one turn of a piece of hard laid white line, and extend the two ends, and make them fast to some support; then have a tub of cold water close to you and, grasping the bottle by the neck with one hand and the bottom with another, saw the bottle quickly backwards and forwards for a short time you will soon notice a burning smell caused by the friction of the hard cord. After about one minute's friction, by a side motion of the bottle, throw it out of the line into the water, and then tap against the side of the tub when the bottom will drop off. Carboys can be cut as easily, but being larger, they require two persons to see-saw them backwards and forwards. The line of twine to form the groove must be put on quite tight and then wetted to tighten more, so as not to shift; but let the groove and stout cord be dry. The cutting cord should not be less than ⅛ in. thick; the edge of the glass after cutting should be rubbed on a grindstone, as it is very sharp.

(5) If a bottle is to be cut into two pieces, a notch is filed in its side. Then, by applying a hot iron or glass rod, first on one side then on the other of the notch, a smooth crack ½ in. long will sometimes form. But as this does not always take place, and, as in cutting glass only one of the pieces is wanted, a crack may be started well away from the desired place. Assuming such a crack to be formed, it may be led in any direction by slowly moving in advance of it, and in contact with the glass, the end of a pipe stem, of an iron or a glass rod, heated to a full red heat. The speed with which the rod is to be moved depends on the crack. It should be kept about ¼ in. in advance thereof, and should be moved continually away from the end, as the crack extends itself. In this way a flask can be cut into a spiral, or heavy plate glass divided with fair accuracy.

The great point is to have the line of the cut well marked. If a bottle is to be cut off to make a battery jar for instance, a string tied or a rubber band sprung around it about a ¼ in. from the place of division forms a convenient guide. The cut may be carried around parallel with the string or band. Then a half-hour's grinding on a horizontal pane of glass, with sand, camphor and turpentine, will finish the edge perfectly. In marking a place for cutting, a pointed piece of soap may be used, as a string can only be employed on cylindrical objects. This method of working is attended with one inconvenience. Unless a rod of large size is used, continual reheating is necessary. A glass rod as thick as a penholder will carry a cut about 2 in. at a heat. A pipe stem or tenpenny nail will do the same. To obviate waiting, several rods may be used, some heating while one is in use.

A fine gas jet, burning from a fine glass jet at the end of a rubber tube, has also been suggested, but is inconvenient. Little carbon pencils, that burn with flameless incandescence, may be used instead of a heated rod. These, however, are troublesome to make.

The use of what is sold by the fireworks dealers under the name of punk was suggested by a consideration of the points given above. This substance burns slowly, without flame, and maintains a strong incandescence until quite consumed. The incandescent part takes the shape of a cone like a sharpened pencil. As long as the piece lasts its burning end maintains this form. By blowing upon it the heat can be materially increased. On trial it was found to cut glass perfectly. The only objection to it is that if rubbed against the glass the ash soils its surface, so that the progress of the crack cannot be conveniently watched. But in practice it is not necessary to hold it in contact with the glass, as it radiates heat enough to lead the crack, if held very close and not in absolute contact therewith.

By using punk the trouble of shifting from rod to rod and the necessity of a source of high heat, a Bunsen burner generally, is obviated. The punk can be lighted with a candle, or even with a match, and is ready for use immediately. A long stick will last for ½ hour, enough to do a great deal of work. The only difficulty is in starting the crack. It may be done by heating the glass, and touching it with a drop of water. This generally starts several, and the one pointing in the most convenient direction may be chosen, and carried where desired. The method first spoken of as applicable to bottles, that of filing a notch and heating the glass first on one side and then on the other, cannot be depended on. (S. T.)

(6) This method has been used in cutting cylindrical beer bottles ranging from ⅛ in. to $\frac{3}{16}$ in. in thickness, but also to some extent on flint glass round seltzer bottles ⅜ in. thick. The thick bottles were cut equally well, only requiring a little more time. A blowpipe of some sort is essential. A common blowpipe with gas or candle-flame will do; but a gas blowpipe, consisting of a large-diameter tube for supplying the gas, and a small-bore tube fixed centrally in the large one for furnishing the air jet is much the more convenient. The air jet should be rather fine, so that a short-pointed blue flame of small diameter can be easily produced. Some kind of a support must be provided by means of which the blowpipe can be adjusted and held in any fixed position. Some sort of an arrangement must also be provided by means of which the bottle to be cut can be slowly rotated by hand in a fixed position. This may be vertical, horizontal, or at an angle, as most convenient.

In the case of flat-bottomed bottles this may easily be done for a vertical position by nailing on to the workbench or on to a horizontal board two short wooden cleats in the shape of a V, with the open end towards the operator.

Having arranged the bottle ready for turning as above described, adjust the blowpipe so that the flame will impinge upon the bottle at the place where the same is to be cut, and in a direction normal to the surface at the point of contact. Next provide a pail of cold water deep enough so that the bottle may be immersed in the water, head-down, to a point 1 in. or 2 in. above where it is to be cut. Now rotate the bottle by hand at the rate of about four revolutions per minute, and at the same time cause the finely-pointed blue and intensely hot flame of the blowpipe to play upon the bottle. The best results are usually obtained when the extreme tip of the flame just touches the bottle. After four or five revolutions quickly lower the bottle *vertically* with head down into the pail of water. As soon as the heated portion of bottle touches the water a sharp crack will be heard if the operation is successful, and usually the head of bottle will drop off. Sometimes the two parts must be pulled apart, or the undesired portion knocked off by a sharp blow from a piece of hard wood or light hammer. Should the first attempt be unsuccessful, try a little longer heating. A little practice will make failures very rare. Avoid splashing the water when lowering bottles into same, or irregular fractures are liable to result. An old file applied to the sharp edges of the severed parts will make them safe to handle. ('English Mechanic.')

(7) Cutting bottles will not ruin a diamond any more than cutting "cathedral-glass" or "rough-rolled" if done by anyone used to it; but amateurs are likely to ruin a diamond even on plain window-glass, through not understanding how a diamond ought to act, therefore the following may be recommended: Bind a straight strip of thin wood or cardboard around the bottle to act as ruler or guide, and tie firmly with twine; then with a steel wheel glass-cutter (price from 6*d*. to a 1*s*.) go once around slowly and rather heavily, taking care not to miss a part; remove the cardboard or wood and make the poker red-hot for 2 in. or 3 in., and lay across the bottle, working it up and down a little in the direction of the cut. This will start a "flaw." Continue the same all round, keeping poker a little ahead of the flaw. I have cut scores for my own use, but I prefer to use a diamond.

Darkening.—The following, if neatly done, renders the glass obscure yet diaphanous: Rub up, as for oil colours, a sufficient quantity of sugar of lead with a little boiled linseed-oil, and distribute this uniformly over the pane, from the end of a hog-hair tool, by a dabbing, jerking motion, until the appearance of ground glass is obtained. It may be ornamented, when perfectly hard, by delineating the pattern with a strong solution of caustic potash, giving it such time to act as experience dictates, and then expeditiously wiping out the portion it is necessary to remove.

Drawing on (*and see* MARKING ON *and* WRITING ON).—Grind lampblack with gum-water and common salt; draw the design with a pen or hair pencil; or use a *crayon* made for the purpose.

Drilling (*see also* CHINA RIVETING). (1) For drilling holes in glass a common steel drill, well made and well tempered is the best tool. The steel should be forged at a low temperature, so as to be sure not to burn it, and then tempered as hard as possible in a bath of salt water that has been well boiled. Such a drill will go through glass very rapidly if kept well moistened with turpentine in which some camphor has been dissolved. Dilute sulphuric acid is equally good, if not better. It is stated that at Berlin glass castings for pump-barrels are drilled, planed and bored like iron ones, and in the same lathes and machines, by the aid of sulphuric acid. A little practice with these different plans will enable the operator to cut and work glass as easily as brass or iron.

(2) Small, rough, refuse diamonds, set in the end of a tin tube, make effective drills for glass.

(3) Richter and Co., Chemnitz, have a way of impregnating thin German silver discs (15 to 25 mm. diameter) with diamond, so that when fitted to a quickly-rotating tool, these cut through glass or porcelain in a few seconds, or effect any desired carving with great accuracy. With cylinders made on the same principle, round holes can be quickly and exactly made. The wear of the implement, even after much use, is hardly perceptible.

(4) A simple method of perforating glass with the electric spark is described by Fages. The apparatus required consists (*a*) of a rectangular plate of ebonite, its size, for a coil giving 12-centimetre sparks, about 18 centimetres by 12; (*b*) of a brass wire passing under the plate and having its pointed end bent up and penetrating through the plate (not farther). This wire is connected with one of the poles of the coil. A few drops of olive-oil are placed on the ebonite plate about the point, and the piece of glass to be perforated is superposed, care being taken not to imprison any bubbles of air. The olive-oil perfectly accomplishes the object of insulating the wire. One has then only to bring down a wire from the outer pole of the coil, on the piece of glass, above the point of the lower wire, and pass the spark. By displacing the glass laterally, for successive sparks, it is easy to make a close series of holes in a few seconds.

(5) Glass can be drilled with a com-

mon drill, but the safest method is to use a brooch drill. No spear-pointed drill can be tempered hard enough not to break. The brooch can either be used as a drill with a bow, or by the hand. It should be selected of such a bore that it will make a hole of the required size, at about one inch from the end. It should be broken off sharp with a pair of pliers, at about 1½ in. and when the sharp edges are blunted by drilling, a fresh end should be made by breaking off ⅛ in., and so on, until the hole is bored. It is always desirable to drill from both sides as it prevents the glass from breaking; drill lightly, and lubricate with spirits of turpentine and oil of lavender, or a little camphor instead of oil of lavender. Holes may be drilled through plate glass with a flat-ended copper drill and coarse emery and water. The end of the drill will gradually wear round, when it must be re-flattened, or it will not hold the emery. Practically, however, the best means of drilling holes in glass is by using a splinter of a diamond. A brass drill is made to fit the drill-stock, sawn down a little way with a notched knife to allow the splinter to fit tight, and the splinter fixed in the split wire with hot shellac or sealing-wax. The drill is used quite dry and with care. If the hole to be drilled is wanted larger than the tool, drill a number of small holes close together to form a circle as large as the hole required, then join the holes with a small file. A splinter of diamond may be bought for 2*s*. big enough to drill a ¼ in. hole.

(6) Glass may be readily drilled by using a steel drill hardened, but not drawn at all, wet with spirits of turpentine. Run the drill fast and feed light. Grind the drill with a long point and plenty of clearance, and no difficulty will be experienced. The operation will be more speedy if the turpentine be saturated with camphor. With a hard tool thus lubricated glass can be drilled with small holes, say up to $\frac{3}{16}$ in., about as rapidly as cast steel. A breast or row drill may be used, care being taken to hold the stock steady, so as not to break the drill.

(7) To file glass, take a 12 in. mill file, single cut, and wet it with the above solution—turpentine saturated with camphor—and the work can be shaped as easily and almost as fast as if the material were brass.

(8) To turn in a lathe, put a file in the tool stock and wet with turpentine and camphor as before. To square up glass tubes, put them on a hard wood mandrel, made by driving iron rod with centres through a block of cherry, chestnut, or soft maple, and use the flat of a single cut file in the tool post, wet as before. Run slow. Large holes may be rapidly cut by a tube-shaped steel tool cut like a file on the angular surface, or with fine teeth, after the manner of a rose bit; great care being necessary, of course, to back up the glass fairly with lead plates or otherwise to prevent breakage from unequal pressure. This tool does not require an extremely fast motion. Lubricated as before, neat jobs of boring and fitting glass may be made by these simple means. The whole secret is in good high steel, worked low, tempered high, and wet with turpentine standing on camphor.

(9) The method usually recommended for boring a hole of considerable size in glass is by means of a copper tube fed with emery and turpentine. This may answer better in a vertical drilling machine than in the lathe, but amateurs who are not ordinarily happy enough to possess the former appliance will usually employ the lathe, wherein it does not prove a very satisfactory process, being difficult to manage, horribly dirty, and exceedingly slow. The pressure necessary also causes a piece to be punched out with chipping of the edges of the hole at the back before the drill-tube goes clean through.

It is, of course, quite easy to drill small holes in glass by means of a properly hardened spear-pointed steel drill running at 100–200 revolutions per minute, and having to bore some

1 in. holes in discs of plate-glass 3 in. diameter, I thought it worth while to try what could be done with a steel tool. After several trials this finally assumed the form of a square-ended bar ground flat on one end, so as to have 4 working edges, and as a graver tool on the other, for clearing out the circumference of the hole as it progresses, and made very hard by getting, as the smiths say, "all the water."

A couple of the discs were fixed together with turners' cement, and fixed centrally on a wooden face-plate by the same means. When cold, the square-nosed tool, held at an angle of 45° to the horizontal, point downwards over the T-rest, had one of its edges pressed firmly against the revolving glass. The lathe was driven at about 60 per minute, and the work lubricated by just dipping the tool occasionally in turpentine. Too much turpentine flowing over the work does not answer. The action is not exactly a cutting one, but seems rather a kind of local breaking up of the glass immediately under the edge of the tool, which goes on evenly after the finest edge of the tool is lost, and is apparently the same as that which occurs in using the small drills for glass.

The hole, however, went merrily and cleanly through the outside plate without any considerable chipping at either surface. The graver point was used when necessary to keep the sides of the hole parallel. When, however, the outer plate was wedged off by the insertion of a knife blade, and the second proceeded with, some chipping occurred at the inside surface, since the wood backing did not give a sufficiently solid support. For this the remedy is easy and obvious. (J. Brown.)

(10) To make a small hole in a plate of glass is a comparatively simple matter. All that is required to do it is a very hard, sharp drill, some means for turning it, and a lubricant, such as turpentine, for causing the drill to cut rapidly. A drill made in the usual form from steel wire and hardened by heating it until it is dark red and then plunging it in mercury, will be very hard, but not tough. Before the drill is heated it should be driven into a block of lead, so that its point will just be enclosed by the lead, and after the drill has been hardened in the mercury its point should be inserted in the indentation in the lead, and the temper of the shank of the drill should be drawn over a lamp or gas flame to a blue. The lead prevents the drill point from becoming heated sufficiently to draw the temper, by conducting the heat away as fast as it arrives at the point. When the shank of the drill becomes blue to within a short distance of the lead, the drill, together with the lead, should be plunged into cool water.

The drill prepared in this way should be wet with turpentine while in use, to cause it to "take hold." It is advisable to drill from opposite sides of the glass whenever this is possible. The hole may be enlarged by means of a sharp round file wet with turpentine. When larger holes are required, these cannot conveniently be made with a drill. A copper or brass tube charged with emery and water or emery and turpentine and rotated in contact with the glass, will soon cut a hole a little larger than the tube.

Simple ways of guiding and revolving the tube are shown in Fig. 215. The glass to be drilled, which may be the plate of an electrical machine for example, is placed upon a table with a few thicknesses of paper underneath its centre. Two blocks are placed on the table at diametrically opposite edges of the disc and a thick bar of wood, which is bored at the centre to receive the copper or brass tube, is placed upon the blocks and clamped firmly to the table. The glass plate is arranged so that its axis coincides with that of the hole in the bar. The plate is then clamped in place by gently inserting two wooden wedges between the wooden bar and the glass.

The tube by which the cutting is done is stopped by a wooden plug at the middle of its length, and in the upper part is inserted a soft rubber stopper which rests upon the wooden plug, also a piece of heavy rubber tubing which rests upon the stopper. In the rubber tube is inserted one end of a close-fitting metal shank, the other end of which is fitted to an ordinary drill stock. This arrangement provides for a certain amount of flexibility in the connection between the tube and the drill stock. The tube is revolved by the gearing of the drill stock while it is supplied with a mixture of No. 4 emery and water or emery and turpentine. The pressure on the drill stock should be light and the tube must be lifted frequently to allow a fresh supply of emery to reach the surface being cut. This device makes a hole in the glass in a short time.

If a larger aperture is desired, the glass is first drilled in the manner described, and enlarged by careful cutting with a diamond. ('Scient. Amer.')

Enamelling. (*See also* ENAMELLING.)—An enamel paint may be either an exceedingly fusible glass, covered by some metallic oxide, and rendered opaque by the presence of arsenic trioxide, or an equally fusible transparent glass mixed with some opaque infusible powder. It is always applied as a pigment, and is fixed to the glass background by heat. It is essentially a glass, and by heat should become partially incorporated with the glass upon which it is painted. There is little doubt that, in former times, artists ground up for their paint some of the self same glass as that with which they were glazing their windows. Paints formed in this manner require for proper fusion the actual melting-heat of the glass to which they have been applied. The pieces of glass background are therefore usually found to be injured and distorted when removed from the kiln. To obviate this defect, it has become customary to fix the paint by means of a glass very much more fusible than the glass used for glazing. Such may be produced by the addition of a considerable proportion of borax to the raw material of fluid glass, or by the diminution of the proportion of silica in the same glass. One of the first requirements in a window is that it shall keep out the weather. Any decoration, therefore, that happens to be on the outside of the glass must be able to resist the action of the atmosphere. Internal decoration is at the same time exposed to the continued action of the products of human respiration, viz. moisture and carbonic acid, as well as to the moisture always present in the air. The borax contained in an enamel paint is rendered anhydrous by fusion, but after lengthened exposure, it reabsorbs moisture, and becomes hydrated and efflorescent. The efflorescence of the borax means the decay of the glass used to fix the pigment to the background. After efflorescence has continued for some time, the pigment begins to flake off, and finally the background is denuded of ornament. Very few of the pigments sold at the

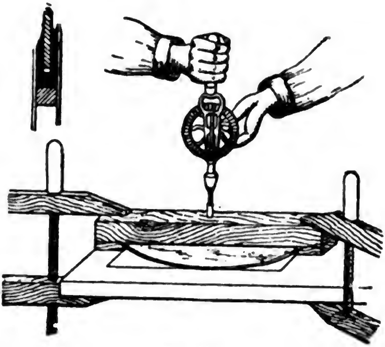

FIG. 215.

present time for the decoration of glass do not contain borax. The use of such pigments upon work intended to be permanent should be carefully guarded against. Flint-glass, rendered more fusible by the reduction of the proportion of silica, is not liable to efflorescence when used as a fixative; care, however, must be taken in preparing the fixative, that the raw materials are mixed in combining proportions. If there be an excess of any ingredient decay must necessarily follow. A glass formed according to the formula PbO. $K_2O.4SiO_2$, which is the same as that of flint optical glass, will be found sufficiently fusible for use as a fixative, and will resist the action of the atmosphere. The legitimate use of enamel paint for the permanent decoration of glass is in the form of a dark brown or red opaque colour, for outlines and shading. This is prepared by carefully grinding and mixing with the powdered fusible glass a proportion of ferric oxide, cupric oxide, or black oxide of cobalt. Iridium oxide is also occasionally employed. The colour is applied to the surface of glass in the same manner as an ordinary pigment. Shadows may be represented by 1 of 3 methods, or by a combination of the same: (1) by colour applied in a mass known as "smear shadow"; (2) by thin lines of colour interlaced known as "cross-hatching"; (3) by a mass of colour allowed partially to dry and then disturbed by the action of a soft-haired brush, known as "stipple" shadow. By the last method, the colour is scattered in separate particles, and a certain amount of light is allowed to pass, which gives an effect of transparency. The effect of high light is obtained by removing with a sharp point, parts of a smear shadow.

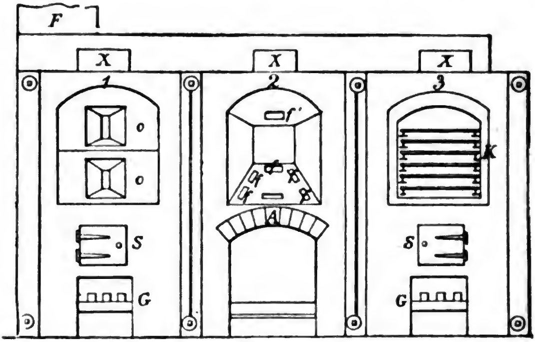

FIG. 216.

Kilns.—The kilns used for burning-in stain and enamel are represented in Fig. 216. 1, 2, 3 may be regarded as the same kiln in different conditions; S is the firing-door; G, the grate; o, cast-iron screens, placed one upon the other, with protruding openings to allow the stoker to watch the progress of the glass within; K, cast-iron casing or muffle, with iron shelves resting upon ridges projecting from the sides of the muffle, upon which the pieces of glass lie; the inside of the muffle is always carefully coated with whiting, and the shelves are covered with a layer of plaster of Paris, in which the glass is imbedded; *f*, openings allowing the fire to pass from the grate, and through the arch A, in such a manner as to surround the muffle, and to pass off through f' into the main flue F; X, soot-doors. (Powell, 'Spons' Ency.')

Frosting.—(1) Roll up tolerably tightly a slip of tin, about 6 in. or 8 in. long and about 2 in. broad, or use a small flat piece of marble. Dip either of these in Croydon or glass-cutters' sand, moistened with water; rub over the glass, whether flat or round, dipping it frequently in a pail or pan of clear water. This is the method employed for frosting jugs, etc. For lamp glasses a wire brush is used, and they are chucked in a lathe. Panes of glass should be laid on a soft bed of baize, or coarse linen. If the frosting is to be very fine, finish with washed emery and water. As a temporary frosting for windows, mix together a strong, hot solution of sulphate of magnesia and a clear solution of gum arabic, apply warm. Or use a strong solution of sulphate of sodium warm, and when cool wash with gum-water to protect the surface from being scratched.

(2) Make a saturated solution of alum in water, and wet the glass with the liquid. It is advisable to have the glass in a horizontal position, so that the solution is not likely to drain off. The more slowly it is cooled, the more perfect will the crystals be; you can with that intention warm the glass. You may, if you choose, colour the alum solution with cochineal, and of course the more solution you use the thicker you will have the crystals.

(3) Verre Givre, or hoar-frost glass, an article now made in Paris, is so called from the pattern upon it, which resembles the feathery forms traced by frost on the inside of the windows in cold weather. The process of making the glass is as follows: The surface is first ground either by the sand blast or the ordinary method, and is then covered with soft varnish. On being dried, either in the sun or by artificial heat, the varnish contracts strongly, taking with it the particles of glass to which it adheres; and as the contraction takes place along definite lines, the pattern produced by the removal of the particles of glass resembles very closely the branching crystals of frostwork. A single coat gives a small, delicate effect, while a thick film, formed by putting on two, three, or more coats, contracts so strongly as to produce a large, bold design. By using coloured glass, a pattern in half-tint may be made on the coloured ground, and after decorating white glass the back may be silvered or gilded. (*See* CRYSTALLINE.)

(4) New method of deadening and graining glass and mirror plates.—Coat the places which are not to be affected by the acid with varnish. For deadening place the respective plates vertically in the mixture and for graining horizontally one upon the other. In the latter case the plates are separated by small wooden or metallic blocks. The mixture consists of a completely saturated solution of soda or potash in hydrofluoric acid. Add four or five times its weight of water to the mixture and then 1 quart of acetic acid to every 30 or 40 quarts of fluid. The coating of varnish can, after the operation, be readily removed by dipping the glass into water saturated with potash and ammonia or into bisulphide of carbon.

(5) A very simple way of using an abrasive gritty substance for matting any parts of glass (the parts to be clear being protected by a paper pattern or stencil) is to let medium grade emery (grit emery, not flour) run through a vertical tube 5 ft. or 6 ft. long, a funnel being at the upper end where the emery is poured in. It is rather remarkable how quickly this will cut the surface, for with, say, 3 lb. of emery, it will only require to be run through three or four times to mark the design quite plainly. This would be with flat surfaces. If a round bottle, or tumbler, had to be marked this would have to be rotated slowly either by hand or by a simple machine driven by a spring or suspended weight.

Iridescent.—The lustrous, metallic-looking glass, of iridescent quality, is, it appears from the English patent of Mr. Thomas W. Webb, produced in the following manner: Chloride of tin, or tin salt, is burnt in a furnace, and the glass having an affinity for it, when hot, receives the fumes, and so at once an iridescent surface is produced. To give greater depth to the colour or tints, nitrate of barium or strontium is used in small proportions. By this patent the glass is not re-heated, but the iridescence is produced during the manipulation of the article when in the hands of the blower, and while on the punty.

Marking on Glass *(and see* DRAWING ON GLASS *and* WRITING ON GLASS).—Chalk is too hard, while pipe-clay though moderately successful, is not soft enough. Soap, cut into sticks, serves best, and it can be readily cleaned off when the marks are no longer needed.

Matting Acid (*and see* ETCHING ON GLASS).—This is commonly called white acid, and consists of 4 parts of hydrofluoric acid, 3 parts carbonate of ammonia and 2 parts water, all by weight. Or a white acid for the same purpose is made by simply dropping lump ammonia into hydrofluoric acid until effervescence ceases.

Ornamenting.—Some ornamental processes during manufacture are: (1) Upon the surface of a vessel in course of manufacture, small drops or seals of molten coloured glass may be fixed, and may be pressed by moulds into the form of stars, gems, etc. (2) A small quantity of molten glass is gathered upon the end of a working-rod, and allowed to lengthen by the force of gravity; the free end is attached to some point on the body of a vessel in course of manufacture, and the vessel is rapidly rotated; thus a thread is evenly coiled around the vessel. A machine is now being used for causing the vessel attached to the blow-pipe to revolve more evenly and rapidly than can be effected by the unaided skill of the workman. (3) If, after the first gathering, the bulb of white glass be dipped into a crucible containing coloured glass, a vessel may be formed with a coloured casing. In preparing coloured glasses for casing, great care must be taken that they shall neither be harder nor softer than the white metal, or the vessel formed is sure to crack. (4) If a bulb of molten glass be rolled upon variously coloured powdered glasses, flakes of mica, or leaves of gold, silver, or platinum, it will adhere to them, and, by continuous rolling, will amalgamate with them. Very beautiful effects of colour may be obtained in vessels made from glass prepared as described. (5) Iridescence, which is due to inequality of surface, may be produced by the action of an acid, or of the fumes of chloride of tin, upon the surface of glass. The glass, whilst hot, is subjected to the fumes of chloride of tin during manufacture. Any acid process must take place after the glass is annealed and cold. To effect iridescence, weak solutions of hydrofluoric or hydrochloric acids may be used. In the latter case, the process takes place in heated air-tight vessels. (6) Glass vessels may be frosted by plunging them, whilst still red-hot, into cold water, and afterwards reheating them. (7) Etchings in gold-leaf may be introduced into the substance of a vessel in the following manner: The gold-leaf is floated on to a thin plate of glass, and etched. The plate of glass is heated, and a mass of molten glass is dropped upon the surface of the gold-leaf, and adheres to the thin plate of glass through the pores in the gold. The molten mass may be fashioned in the glass-house, or by the cutter. (Powell.)

If glass be left in a strong alkaline solution for some months, the surface becomes so eroded that it gives by reflected light the colours of the spectrum in the most brilliant manner. This effect can be produced by ruling very fine lines upon glass plates, but those who have the patience to wait for 3 or 4 months while the glass is in its bath will be highly pleased with the result, and there is no patent on the process, because it is the outcome of an attempt to explain the iridescence found on articles of glass which have been buried for many centuries in moist earth. As to the solution, strong hyposulphite of soda will do, but probably the effects might be more rapidly produced by means of caustic potash or soda; but inferentially any strongly alkaline solution will answer. The common kinds of glass are more readily attacked than the hard varieties; but for ornamenting the ordinary blown water bottles and cast tumblers, basins, and jugs, no process can equal the iridescent. The only drawback is the time. (Mayer.)

Bay's Process for making the new kind of Glass which is smooth on one side and rough on the other (*Craquelé Indien*).—The roughened surface of the glass looks as if it was covered with cracks, and this appearance is obtained by spreading over the surface of a plate of glass a thick layer of some flux or easily fusible glass that has been made fluid or pasty and mixed with coarser pieces. The glass is then put in a muffle or an open furnace and strongly heated. As soon as this flux is melted, and the glass itself becomes red-hot, it is taken out of the furnace and rapidly cooled. This flux or fused glass then cracks off from the other glass which was attacked by it, leaving numerous depressions in the latter, resembling scales and irregular crystalline forms, crossing and intersecting each other, and producing very beautiful effects when the light falls upon it. This fusible layer is cooled as rapidly as possible, either by a current of cold air or by carefully sprinkling with cold water. If some portions of the glass are protected from the action of the flux, the surface remains smooth there, in striking contrast to the crackled portion. This can be utilised in making arabesque letters, and other designs on a white or coloured ground. A similar crackled glass is made in another way, by strewing a coarsely-grained flux on a cylinder of glass while still red-hot, and then putting it back in the heating furnace until the flux melts. It is then rapidly cooled, either by sprinkling water on it or waving it back and forth. The layer of melted flux then cracks off and exposes the surface of the glass which has been corroded by it. The cylinder is then cut and spread out in the usual manner.

Benrath has examined a "muslin" glass from Pivout, Charleroi. The enamel was very regular and homogeneous, and the surface could be readily cleaned; weak acids had no action on the enamel; concentrated nitric acid produced no change in 3 days; sulphide of ammonium, however, gave a greyish tint, whilst liquid hydrofluoric acid showed that the enamel was only incorporated on the surface of the glass. The substance giving the "matt" was very fine and delicate, and of a white tint, with a brownish-yellow shade; dilute acids dissolved out lead oxide and boric acid; hot water had no action on it. Its composition was—

Silica	42·99
Boron trioxide	6·25
Carbonic acid	trace
Stannic oxide	7·01
Lead oxide	37·78
Ferric oxide	0·11
Alumina	0·07
Potash	2·95
Soda (by difference)	2·84
	100·00

which represents a mixture of the following ingredients:—

Sand	100
Litharge	110
Crystal	110
Anhydrous borax	25
Potash stannate	25

('Ding. Pol. Jl.')

Three processes connected with the ornamentation of glass, porcelain, and earthenware, were brought before the Société d'Encouragement, Paris. Cacault, of Colombes, prints, on the fine and hard earthenware of Breil, photographic impressions, which are fixed at a single burning. Lacroix, Paris, has produced pencils like those of graphite, but consisting of various vitrifiable colours. A design executed with them on glass, having the surface slightly dulled, stands the fire, and becomes fixed, like a painting on glass. A similar process, tried on porcelain a few years ago, is said not to have been successful. Lutz-Knechtle, a Swiss, decorates glass, cold, by his composition, made of a solution of silicate of soda or potassium, with the addition of zinc-white or ultramarine. The colours are applied by means of a stamp or roller, dry quickly, and stand washing. The surface of the glass is first finely ground, and any design is then painted on it with a mixture of anhydrous boracic acid, gum, and water. When dry, it is exposed to a temperature at which the boracic acid fuses, and imparts to those portions of the glass the usual lustre, and thus fixes the drawing. By mixing various metallic oxides with the boracic acid, designs in colour may be produced. (Dodé.)

The surface to be ornamented is covered with a sensitive varnish, and the design, being made transparent, is laid on the varnish, and the light is allowed to act on the sensitive film through the picture. After sufficient exposure, the picture is removed, and colours are applied in the following manner: The finely-pulverised pigments or enamels are taken up (in a dry state) by a brush applied to the parts where they are required, which can be clearly distinguished in the layer of varnish on the article. The colours or enamels adhere more or less according to the degree to which the adhesiveness of the varnish has been affected; that is to say, according to lights and shades in the design to be reproduced, or according to whether varnish has hardened more or less. The varnish may be composed of yellow gelatine, gum-tragacanth, and quince-seeds mixed with rain-water, and chrome salts, such as potash bichromate, added, to sensitize it. The composition of the varnish for normal conditions may be—

Filtered water . .	500 parts
Gelatine . . .	1 ,,
Gum-tragacanth .	10 ,,
Quince-seeds . .	3 ,,
Chrome salt (in crystals)	40 ,,

If the atmosphere is very dry, the quince-seeds may be replaced by sugar, glucose, or honey; or these may be used in addition. The proportions are merely approximate, as the exact preparation will have to be varied according to the conditions of the light, the degree of dryness of the air, and other conditions; but practice will readily suggest what is requisite to those skilled in kindred processes. When the oxides have been applied, they are protected by a coat of thick turpentine, such as is known in France as *térébenthine grasse*, attenuated, if required, by common turpentine, and the other superfluous parts of the varnish removed by immersion for 24 hours (more or less) in water acidulated with vinegar or other acid, say pure acetic or hydrochloric. The strength of the bath (viz. the proportion of acid therein) may be varied within reasonable limits, and determines the length of time which the immersion has to last. The more acid in the bath, the shorter the immersion; the weaker the bath, the longer the immersion has to be. The object is then dried, touched up, and further coloured with metallic oxides, if desired, and fired in a kiln. Copies of works of art and the like, such as portraits on glass (whether seen by transparency or by reflection), and either fired or not, whether they are drawn from nature or a copy of photographs, or of other design, are with advantage produced by making 2 or more *fac-simile* copies as above described, the copies being exactly fitted one over the other; 2 copies, whereof one at least is transparent, are sufficient in most cases. Upon one of these, the enamels, metallic oxides, or other suitable colours, may be applied, or it may be touched up after the colours are fired; the second copy is placed over the coloured one, so that all details and contours register exactly in both pictures, and consequently appear as a single image to the eye. The 2 copies are united, especially, if on glass, fired with a flux applied at the edges, so that the 2, being fused together, form a single piece; this may also, when practicable, be effected by the firing which fixes the colours. The manner of uniting the plates by the interposition and fusion of a flux is the one which is preferable. Where a simple ornamental design, or ornamented surface without figures, is desired, it can be obtained upon glass and other articles by applying a varnish composed of asphaltum, pitch, or an equivalent material, dissolved in spirits of turpentine, to which sulphuric ether is added. The plate is then dried, and the design is applied; the plate is next treated with fluoric acid and water, mixed in suitable proportions, then washed in water, and the varnish is removed, as will be readily understood. This manner of proceeding produces plates which have a "frosted" or "crackled" appearance; that is to say, they appear as if covered by numerous vein-like grooves or marks. The varnish for this purpose may consist of—

Asphaltum . .	100 parts
Spirits of turpentine .	50 ,,
Sulphuric ether .	50 ,,

These proportions may vary considerably, and according to their variation will produce a different design. The sulphuric ether may be replaced by light naphtha or by benzoline. The component parts of the varnish do not enter into chemical combination, but merely become mechanically mixed. The mixture is applied to the article by means of a brush or a pad, similarly to "stippling." By this means the non-volatile fatty component parts of the varnish adhere in flakes or patches to the article, and protect it, and the fluoric acid attacks only the parts not so protected, and thereby the design is produced. (Micciullo.)

Crystoleum.—These exceedingly delicate coloured photographs on glass, which have come into fashion somewhat of late, are produced by fixing a paper photograph upon a cushion-shaped glass with transparent cement, and when it is dry, rubbing away two-thirds of the thickness of the photograph by sand-paper. The thin film left is then rendered transparent by soaking in melted paraffin wax, after which transparent colours are applied, which appear softened down when looked at from the front. The background and heavier portions of the picture are then painted in body colour upon the face of another cushion-shaped piece of glass, which is afterwards fixed behind the first one. An improvement in this process was made by Mrs. Nelson Decker. She discovered that the second sheet of glass may be abolished, a better artistic effect be produced, and the picture rendered more permanent, by protecting it from the action of the air and deleterious gases by wholly embedding in paraffin. She does this by quickly dipping the photograph into paraffin a second time after the transparent colours have been applied, and painting the heavier colours upon the back of this second coat. A third layer of paraffin is then applied and the background is painted upon that; this third coat may be finally protected by yet another layer of paraffin. Some practice is necessary to acquire the "knack" of doing this efficiently. It must be done rapidly enough not to re-melt previous layers, and the plate must, after each dipping be quickly tilted on end in such a manner that the paraffin does not run into ridges and thickened lines, but forms an even coating. ('Engineer.')

Polishing Mediums.—There are many, but one commonly used consists of rouge and pitch. The cleanest and quickest is tripoli powder and paper.

Powdering.—Powdered glass is frequently used instead of paper, cloth, cotton or sand for filtering varnishes, acids, etc. It is not soluble or corrodible. Sand, if purely silicious, would be better, but such sand is difficult to get; it too often contains matters which are easily corroded or dissolved. Powdered glass, when glued to paper is also used for polishing wood and other materials. It cuts rapidly and cleanly, and is better than sand for most purposes. Glass is easily pulverised after being heated red hot and plunged into cold water. It cracks in every direction, becomes hard and brittle, and breaks with keenly cutting edges. After being pounded in a mortar it may be divided into powders of different degrees of fineness by being sifted through lawn sieves.

Protecting.—(1) In chemical laboratories it is customary to put a coating of clay on glass vessels that are to be exposed to a temperature that would soften or melt the glass, or where they are liable to be broken by draughts of air. Sometimes cows' hair or asbestos is mixed with the clay to strengthen it. Although this mass is cheap, it is liable to fine checks and cracks, or it scales off, which frequently causes the glass to break. The disadvantages referred to can be entirely overcome by mixing up the materials with a little glycerine. This cheaply and easily prepared mass is thus rendered very easy to apply, always retains its desired softness, and never cracks nor checks. ('Gewerbeblatt.')

(2) I have recently been using, with better results, a mixture of infusorial earth and water-glass, which, if properly applied, will last for weeks, and hence is not expensive, while it protects and strengthens the vessel to such an extent that I have, for the sake of experiment, heated thick but cracked retorts that were protected in this way to 400° or 500° C. (932° F.) when exhausted almost to a vacuum, and yet they did not break or collapse. It is important to make this mixture so that it shall form a soft and somewhat elastic, but not liquid, paste. A mixture of 1 part by weight of infusorial earth with 4 or 4½ of water-glass will fulfil this end approximately; the exact proportions cannot be given, because commercial water-glass differs in strength, and the infusorial silica is not always dry. The part of the vessel to be protected is covered ⅛ to ⅜ in. thick, and dried at not too high a temperature; it is better to dry in a drying closet or on a support over the stove. If the temperature is too high at first, it will cause air bubbles in the mass, and it is not so good then. It can be dried by swinging it back and forth over a flame, the bubbles being prevented by pressing them out. If a crack appears, it is plastered over with more of the mixture, and allowed to dry again. If some parts of the vessel are to remain transparent, they may be protected by water-glass alone, by applying several thin coats, and letting each dry before putting on the next. The same mass can be used to cover gas retorts, furnaces, stoves and walls, just as well as for glass and porcelain utensils. (Schaal.)

Roughening (*and see* ETCHING *and* FROSTING).—This may be produced by the recently-invented sand-blast process, based upon the principle that if a stream of sand be made to fall through a vertical tube open to the air at the top, and the falling sand and air be received in a suitable closed vessel below, a jet or current of compressed air can be obtained. The entire surface of a vessel may thus be roughened, or, if parts are protected by a suitable medium, only the exposed portions will be abraded. By this means, very delicate patterns may be produced. Glass may be etched by the action of hydrofluoric acid, either in solution or in the form of gas. The variety in depth of incision, which gives the chief beauty to engraved glass, cannot be gained by either of these processes.

Spun.—To make fine glass thread, the glass is brought to a state of fusion, a glass rod is dipped in it, and thus a thread is pulled out, which solidifies first in its thinnest parts, and so causes a uniform thickness to be obtained. If this thread is placed over a hot metallic cylinder, and the latter is revolved, any length of thread may be obtained, and finer by revolving the cylinder more rapidly. The heating of the cylinder has the effect of annealing the glass to some extent, while the rapid cooling, if wound on a cold cylinder, would make it more brittle. A bundle of such threads looks like a bunch of silk, and it has therefore been called glass silk. It is largely used for filtering liquids in laboratories. In the microscope, the threads are as fine as those of silk or fibrillæ of cotton; they break more easily than the latter, but are excessively supple. From the unalterability of the substance, it is very well suited for filtering acid or alkaline solutions, even concentrated, and various other substances, such as nitrate of silver, albumen, collodion, Fehling's liquor, etc. It affords great rapidity of flow, with good filtration; it does not, like filters of paper or tissue, communicate organic matters to the liquids, altering and perhaps giving them a disagreeable taste. It is much preferable to asbestos, which, from the arrangement of its parallel fibres, cannot be formed into a flexible ball, and which lets fragments pass that float in the liquid. For analysis it is very advantageous, allowing of a ready determination of insoluble matters deposited; also by calcination and fusion of the glass may be found the volatile principles fixed in the passage of the liquid, unmixed with empyreumatic products. Notwithstanding, the price of glass silk is still high, it is no great expense to use it, as its excessive lightness admits of a considerable number of filtrations being made with a small weight of it; besides, it may serve an indefinite time, if after each operation, it is thoroughly washed with water and dried in the air.

Stencilling on.—Stencil plates may be cut out of thin sheets of metal or cardboard, in the same manner as for wall decoration, etc. If varnish colours are employed, lay them on as evenly as possible, through the perforations in the plate, and harden afterwards in a stove or oven. The metallic preparations used in glass staining and painting are also available, but require firing in a muffle, or a china-painters' stove. Should the process commonly called embossing be wanted, paint the portions of glass left uncovered by the spaces in the stencil plate with Brunswick black, dip or cover with hydrofluoric acid, wash in clear water and remove the black ground. Every part that was covered will then present a polished even surface, the remainder will have been eaten into by the acid. If the raised parts are to have a frosted appearance, rub them with a flat piece of marble moistened with fine emery and water. For putting patterns or lines on glass with a wheel, there are two methods, one followed by glass cutters, the other by the engravers on glass. According to the first-mentioned, rough in the pattern with an iron mill supplied with a trickling stream of sand and water, smooth out the rough marks on a wheel of York or Warrington stone, polish on a wooden wheel of willow or alder powdered with pumice, and finish on a cork wheel with putty and rotten-stone. The engraver cuts in and roughs the pattern with copper wheels, aided by emery of various degrees of fineness, and olive or sperm oil, and polishes the portions intended with leaden discs and very fine pumice powder and water.

Stoppers, fitting.—(1) Very few stoppers properly fit the bottles for which they are intended. The stoppers and bottles are ground with copper cones, fed with sand and made to revolve rapidly in a lathe, and the common stock are not specially fitted. To fit a stopper to a bottle that has not been ground, use emery or coarse sand kept constantly wet with water, and replaced with fresh as fast as it is reduced to powder. When all the surface has become equally rough, it is considered a sign that the glass has been ground to the proper shape, as until that time the projecting parts only show traces of erosion. This is the longest and hardest part of the work, as after that the glass simply needs finishing and polishing. For that purpose emery only can be used, owing to the fact that the material can be obtained of any degree of fineness, in this respect differing from sand. Otherwise the operation is the same as before, the emery being always kept moistened, and replaced when worn out. The grinding is continued until both the neck of the bottle and the stopper acquire a uniform finish, of a moderate degree of smoothness, and until the stopper fits so accurately that no shake can be felt in it, even though it be not twisted in tightly.

(2) In stoppering a bottle, there are 2 processes: (*a*) The mouth of the bottle is opened to the required size by a steel cone revolving in a lathe; (*b*) the stopper is fixed in a wooden chuck, reduced to proper dimensions, and finally ground into the mouth of the bottle.

Transferring Engravings to Glass.—Metallic colours, prepared and mixed with fat oil, are applied to the stamp on the engraved brass or copper. Wipe with the hand in the manner of the printers of coloured plates; take a proof on a sheet of silver paper, which is immediately transferred on the tablet of the glass destined to be painted, being careful to turn the coloured side against the glass; it adheres to it, and so soon as the copy is quite dry, take off the superfluous paper, by washing it with a sponge; there will remain only the colour transferred to the glass, which will be fixed by passing the glass through the ovens.

Transferring Prints to Glass. Take of gum sandarach, 4 oz.; mastic, 1 oz.; Venice turpentine, 1 oz.; alcohol, 15 oz. Digest in a bottle, frequently shaking, and it is ready for use. Directions: Use, if possible good plate-glass of the size of the picture to be transferred, go over it with the above varnish, beginning at one side, press down the picture firmly and evenly as you proceed, so that no air can possibly lodge between; put aside, and let it dry perfectly, then moisten the paper cautiously with water, and remove it piece-meal by rubbing carefully with the fingers, if managed nicely, a complete transfer of the picture to the glass will be effected.

Tubes, sealing.—To seal tubes hermetically after gases have been admitted under pressure, the following arrangement was employed with complete success: The experimental tube A is joined to a T-piece B, the lateral limb of which is constructed, as shown in Fig. 217; a glass plug D is ground into the tube at E, and serves the purpose of a valve opening inward. When gas under pressure is allowed to enter the tube at G, the valve opens, but on

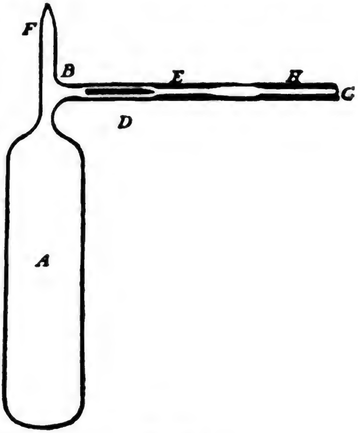

Fig. 217.

removing the pressure from without it at once closes; the escape of gas from A is thus prevented, and the tube may be sealed before the blow pipe at H. When a tube contains a liquid, the plug should be moistened with it; this will prevent the escape of gas while the tube is being sealed, even though the plug does not fit very accurately. In the absence of any liquid, greater care in grinding the plug is required. The tube F serves for the admission of liquid into the experimental tube in the first instance; it is then closed, and at the end of the experiment it is opened, and the contents of the tube are removed. The rest of the apparatus is thus kept intact, and may be used repeatedly, especially if the tube at H is fairly long. (A. Richardson, in 'Chem. News.')

Windows.—*Crown glass* is made in circular disks blown by hand; these disks are about 4 ft. diameter, and the glass averages about $\frac{1}{12}$ in. thick. Owing to the mode of manufacture, there is a thick boss in the centre, and the glass is throughout more or less striated or channelled in concentric rings, frequently curved in surface, and thicker at the circumference of the disk. Consequently in cutting rectangular panes out of a disk there is a considerable loss, or at least variety in quality: one disk will yield about 10 sq. ft. of good window glass, and the largest pane that can be cut from an ordinary disk is about 34 × 22 in. The qualities are classified into *seconds*, *thirds*, and *fourths*.

Sheet glass is also blown by hand, but into hollow cylinders about 4 ft. long and 10 in. diameter which are cut off and cut open longitudinally while hot, and therefore fall into flat sheets. A more perfect window glass can be made by this process, thicker and capable of yielding larger panes with less waste. Ordinary sheet glass will cut to a pane of 40 × 30 in., and some to 50 × 36 in. It can be made in thicknesses from $\frac{1}{20}$ in. to $\frac{1}{2}$ in.

Plate glass is cast on a flat table and rolled into a sheet of given size and thickness by a massive metal roller. In this form, when cool, it is *rough plate*.

Ribbed plate is made by using a roller with grooves on its surface. Rough and ribbed plate are frequently made of commoner and coarser materials than polished plate, being intended for use in factories and warehouses.

Polished plate is rough plate composed of good material and afterwards polished on both sides, which is done by rubbing two plates together with emery and other powders between them. Plate glass can be obtained of almost any thickness, from $\frac{1}{8}$ in. up to 1 in. thick, and of any size up to about 12 × 6 ft.

In the glazing of a window the sizes of the panes, that is to say, the intervals of the sash-bars, should be arranged if practicable, to suit the sizes of panes of glass which can conveniently be obtained, so as to avoid waste in cutting; this consideration is of more consequence in using crown and sheet glass than with plate glass. The woodwork of the sash should receive its priming coat before glazing, the other coats should be put on afterwards. With crown glass, which is sometimes curved, it is usual to place the panes with the convexity outwards. When the glazier has fitted the pane to the opening with his diamond, the rebate of the sash-bar facing the outside of the window, he spreads a thin layer of putty on the face of the rebate and then presses the glass against it into its place, and, holding it there, spreads a layer of putty all round the side of the rebate, covering the edge of the glass nearly as far as the face of the rebate extends on the inner side of the glass, and bevelling off the putty to the outer edge of the rebate. The putty is then sufficient to hold the pane in its place, and hardens in a few days. The glass should not touch the sash-bar in any part, on account of the danger of its being cracked from any unusual pressure; there should be a layer of putty all round the edges. This precaution is especially necessary in glazing windows with iron or stone mullions or bars.

Writing on (*see also* DRAWING ON *and* MARKING ON).—(1) Ether, 500 gr.; sandarach, 30 gr.; mastic, 30 gr. Dissolve, then add benzine in small quantities, till the varnish, spread on a piece of glass, gives it the aspect of roughened glass. The varnish is used cold. To have a homogeneous layer, pour over that already formed some oil of petroleum, let it evaporate a little, then rub in all directions with cambric cloth till all is quite dry. With ink or lead pencil, lines can be produced on this surface as fine as may be desired. Thus a drawing may be prepared in a few minutes and immediately projected. (Crova.)

(2) The glass is to be first gently heated at a spirit lamp or gas flame till steam ceases to be deposited on it, up to 112° or 140° F. (44° to 60° C.). Then a particular varnish should be poured upon it, as is done in photographic operations with collodion. This varnish is composed of 51 dwt. alcohol, 61 gr. mastic in drops, and 122 gr. pounce. The resins are dissolved by being heated in a hot water bath, the whole being in a flask corked and fastened. The solution is afterwards filtered. The varnish is very hard, and becomes brilliant and completely transparent. If it is poured on the cold glass, it becomes opaque and absorbs ink. Drawings may be executed upon it with common or Indian ink. Then a thin layer of gum is put upon it by dipping the glass in a very diluted solution of gum or any other non-alcoholic coating. This process might be advantageously employed instead of labels on bottles in laboratories, and for making figures on glass, and perhaps for tracing drawings, which might thus be reproduced by photography. (Terquem.)

(3) A mixture of flour, ammonia hydrate, and hydrochloric acid, thickened with gum acacia, forms an ink by which, with a pen, letters or ornaments may be traced on glass, where they will become permanent.

(4) Faber makes pencils for writing upon glass, porcelain, metal, etc., as follows: *Black*: 10 parts lampblack, 40 white wax, 10 of tallow. *White*: 40 white-lead, 20 wax, 10 tallow. *Blue*: 10 Berlin blue, 20 wax, 10 tallow. *Dark Blue*: 15 Berlin blue, 5 gum-arabic, 10 tallow. *Yellow*: 10 chrome-yellow, 20 wax, 40 tallow.

(5) Dissolve chalk in aqua fortis to the consistency of milk, and add to that a strong solution of silver. Keep this in a glass decanter well stoppered. Then cut out from a paper the letters you would have appear, and paste the paper on the decanter or jar, which you are to place in the sun in such a manner that its rays may pass through the spaces cut out of the paper, and fall on the surface of the liquor. The part of the glass through which the rays pass will turn black, while that under the paper will remain white. Do not shake the bottle during the operation. Used for lettering jars.

* * *

GLASS-PAPER, SAND AND EMERY PAPER AND CLOTH.

(*a*) THESE sheets of abrasive substances are all practically made in the same way. In the case of those with paper backing an important feature in the wearing quality is that the paper shall be tough; and it must be of fair substance or thickness, otherwise it will not have sufficient stiffness for proper working.

In preparing the glass, sand, or emery, it is necessary to have it quite clean and sifted into the different grades of coarseness or fineness. The glass is crushed in a mill (usually with stone rollers) and, after sifting, is ready for use. Sand must be washed and dried, and it is essential that it be sharp sand, having sharp points and edges (not sea sand, for instance, which is rounded on its edges by constant friction) and on this account it is desirable that it be crushed to some extent so as to give it new fractured edges.

Emery can also be crushed though it is a far harder material than glass or sand (which are both the same material, silica or flint), and unless manufacture on a large scale is proposed, it is best to buy this ready powdered, it being readily procurable in any degree of fineness or grade from "flour" to a coarse grit.

There is a fine grade of sand paper, known in some instances as stone-paper, this having a surface of pumice powder.

The backing used for emery or glass cloth (we have no sand cloth) is a fairly strong but cheap quality of calico material. It is moderately stiff in itself, but gains the stiffness possessed by the finished article by the glue used in affixing the abrasive powder.

In putting the abrasive material on the paper or cloth, glue is used, applied evenly and thinly. Any fair quality of glue will do, but with glass paper a light coloured glue is now used by the best makers who have conveniences for bleaching. If a glue sets too hard and brittle, a small addition of glycerine or treacle will afford sufficient flexibility, but, it should be noted, the addition of either of these delays the drying a little.

Having all materials ready, the papers are laid out, or the calico stretched out, and thinly glued. The abrasive material is then sifted on, and allowed to adhere and dry. Any surplus powder is shaken off when the glue is set.

(*b*) *Glass Paper.*—Take any quantity of broken glass (that with a greenish hue is the best), and pound it in an iron mortar. Then take several sheets of paper, and cover them evenly with a thin coat of glue, and, holding them to the fire, or placing them upon a hot piece of wood or plate of iron, sift the pounded glass over them. Let the several sheets remain till the glue is set, and shake off the superfluous powder, which will do again. Then hang up the papers to dry and harden. Paper made in this manner is much superior to that generally purchased at the shops, which chiefly consists of fine sand. To obtain different degrees of fineness, sieves of different degrees of fineness must be used. Use thick paper.

Stone Paper.—As, in cleaning woodwork, particularly deal and other soft woods, one process is sometimes found to answer better than another, we may describe the manner of manufacturing a stone paper, which in some cases, will be preferred to sand paper, as it produces a good face, and is less liable to scratch the work. Having prepared the paper as already described, take any quantity of powdered pumice-stone, and sift it over the paper through a sieve of moderate fineness. When the surface has hardened, repeat the process till a tolerably thick coat has been formed upon the paper, which, when dry, will be fit for use.

* * *

GLASS STOPPERS, LOOSENING.

THIS common cause of annoyance, occurring frequently with scent and smelling bottles, leads to many breakages through unnecessary force being used, and its not being known that there are comparatively simple methods of loosening stoppers that are effective in practically every case. One or other of the following means may be resorted to: (*a*) Place the bottle firmly on a table, and hold it with the left hand. Then apply the right hand to the stopper, and pull it forcibly on one side, using the thumb as a fulcrum at the exterior of the neck of the bottle. If the stopper moves, the motion will be indicated by a ticking kind of noise; and the stopper can then be withdrawn without further trouble. (*b*) By tapping the stopper on alternate sides with the handle of a hammer, or with a piece of wood (not resting it on a hard substance, but holding the bottle in the hand or between the knees) it can frequently be loosened. (*c*) Dip one end of a cloth in boiling water, and then wrap it round the neck of the bottle; the heat causes the neck to expand which allows the stopper more room, whereby it can often be removed with ease. (*d*) Or the flame of a candle or small lamp may be applied to the neck of the bottle with the same effect. But in both cases the operation must be performed quickly, in order that the heat may not get at the stopper and expand it, for if such is the case, it remains as firmly fixed as before. (*e*) Pass a piece of strong twine round the neck of the bottle and fix one end of the string to a hook; the neck will be heated by the friction occasioned by drawing the bottle rapidly backwards and forwards, the bottle being held in one hand, and the free end of the string in the other. The heat expands the neck as before described. (*f*) Stoppers are sometimes fixed by the coagulating or crystallisation of substances between the inside neck of the bottle and the stopper. The application of oil (paraffin is best, as being most penetrating, if the smell is not objectionable), or water, or muriatic acid to the top of the bottle, will often dissolve away so much of the hard matter as to render the removal of the stopper easy. A needle-point should first be run round the joint to remove any coagulated matter. This alone sometimes proves sufficient. (*g*) When the fixed stopper of a glass bottle resists all management—such as warming the neck with a cloth wet with hot water, by tapping, and by the wrench, or by all these in combination—there is another means which will frequently succeed. Let the bottle be inverted, so as to stand on the stopper, in a vessel of water so filled that the water reaches up to the shoulder of the bottle, but not to the label. Two or three nights of this treatment may be required sometimes before the stopper will yield. (*h*) Another method is to use a stopper extractor. This can easily be made out of a block of wood 3 in. square and 2 in. thick, by cutting a hole through its centre large enough to receive the head of the stopper. The use of the above is preferable to pulling out two drawers, sticking the head of the stopper between them, and twisting the bottle round. To apply the extractor, it is placed over the stopper and grasped firmly in one hand, while the neck of the bottle is held by the other. A gentle, but firm and steady twisting motion is then used, care being taken to keep both hands moving in the same plane, but in opposite directions. If the pressure be applied too vigorously or spasmodically or if the lines of the direction of the opposite forces be not quite parallel, there is a danger of wrenching off the head of the stopper or breaking the neck of the bottle. (*i*) A few drops of glycerine may be applied, and the bottle left to stand for a few hours, when the stopper may be easily removed.

GLAZING BRICKS.

White.—As soon as the brick comes from the press it can have its coat of "slip." This is first applied by a soft brush, then the face is dipped in it. It is then allowed to dry slowly which will take from 8 to 10 hours, but it must not be allowed to get quite dry. While it is still somewhat moist the "white body" is applied. The face is simply dipped in this and the brick is then put to slowly dry again. This time it is allowed to get thoroughly dry. The next process is to dip the face in clean cold water, and then immediately dip it in glaze and it is now ready for the kiln. When the glaze is applied and before going to the kiln, all superfluous glaze is brushed off the sides and ends of the brick, where it is not wanted. In the kiln the bricks are put face to face, the two glazed faces coming about an inch apart. Care has to be used in finely straining the slip, body and glaze mixtures; and it will be found that, for best results, the kiln must not be opened until it is cold.

Slip.—12 parts china clay, 15 parts ball clay, 3 parts flint, 28 parts of brick clay (the same as the brick is made of).

White-Body.—6 parts china clay, 2 parts ball clay, 1 part flint, 2 parts felspar.

Hard-Glaze.—6 parts whiting, 6 parts oxide of zinc, 14 parts Cornwall stone, 6 parts plaster of Paris, 70 parts felspar.

Soft-Glaze.—12 parts oxide of zinc, 4 parts plaster of Paris, 14 parts Cornwall stone, 7 parts Paris white, 50 parts flint glass, 50 parts white-lead, 80 parts felspar. (When the clay of the brick will bear a high temperature, the glass and white-lead may be omitted.)

To colour the Glazes.—It is usually found that one part of colouring matter to 7 parts of white body and 1 part to 9 of glaze, is sufficient for good results; all ingredients must be ground fine.

Blue-Green.—8 parts flint, 3 parts oxide of cobalt, 24 parts oxide of chrome.

Cobalt (Sky) Blue.—5 parts oxide of cobalt, 2 parts phosphate of soda, 25 parts oxide of zinc, 18 parts flint.

Green.—4 parts carbonate of cobalt, 4 parts oxide of copper, 12 parts oxide of chrome, 8 parts felspar. A green, more of grass colour is obtained with 12 parts oxide of chrome, 1 part oxide of copper, and 2 parts flint.

Orange.—8 parts oxide of zinc, 4 parts bichromate of potash, 2 parts iron scales, 20 parts pure alumina.

Full-Red.—20 parts crocus, 20 parts oxide of chrome, 15 parts litharge, 15 parts borax, 90 parts oxide of zinc, 6 parts red-iron oxide.

Brown.—2 parts manganese, 2 parts oxide of zinc, 1 part oxide of chrome, 1 part sulphate of baryta. If preferred a brown body colour can be made of 100 parts red marl, 12 parts manganese, 6 parts felspar, 12 to 14 parts china clay.

A Transparent Glaze for bricks, tiles or similar goods, which are of a natural rich colour and good surface, is made of 1 part oxide of zinc to 16 parts white-lead, and 16 parts flint glass; all ingredients must be ground fine. The bricks are first fired in the usual way, then glazed, and fired again at about half the heat of the first firing (this glaze being a soft one).

* * *

GLAZING WINDOWS.

LEAD GLAZING.

SEVERAL makes of glass are employed for this kind of glazing. Amongst these may be specified "sheet" and "plate" glass of various kinds; "coloured glass," either "pot-metal" or "flashed" ("pot-metal" being coloured throughout its substance by the addition of metallic oxide while the glass is in a state of fusion, while the "flashed" glass is white, with one surface covered by a thin film of coloured glass); "flashed" glass being made in ruby, blue, opal, green, violet, and pink. These colours can be also modified to red, orange, amber, and lemon colour by staining. Another species, called "cathedral glass" (rolled and sheet), is generally applied to light tints of a positive colour, and is principally used for glazing the windows of churches. "Antique" glass is made in various shades of colour, and is usually employed in figure work in stained-glass windows. It is an imitation of that which is found in old leaded lights, and is rough, nubbly, and of uneven thickness. It has recently been made with the colouring oxides encased, and also striped with various colours to produce a more striking effect in the fold of garments in figure work. "Aventurine" is a glass made in slabs, and used occasionally in mosaic figure work. It is generally of a brown semi-transparent colour, and has a peculiar striking effect, caused by the suspension of metallic particles, principally copper filings, which is the chief ingredient. "Ambilti" (single and double) is a sheet glass, originally of Italian manufacture, and much prized by glass painters on account of its softness for staining, and generally brilliant appearance. "Quarries" is the term applied to small square pieces of stained glass, such as are used in the borders of windows; and "roundels" and "bullions" are small discs of glass, some made with a knob in the centre, and used in fretwork with cathedral glass.

The use of lead "calmes" for fixing window panes is of great antiquity, the employment of wooden sash-bars being quite a modern innovation. The calmes or leads for the fretwork are slips which may be prepared with a tool known as the "glaziers' vice," wherein a slip of lead is drawn between two horizontal rollers of the thickness of a piece of glass, and the calme, as it emerges from the mill, has a section exactly like the letter I. The German vices are the best, and turn out a variety of lead of different sizes. There are moulds with these vices, in which bars of lead of the proper sizes are easily cast. In this form the mill receives them, and turns them out with two sides parallel with each other, and about $\frac{3}{8}$ in. broad, and a partition connecting the two sides together, about $\frac{1}{8}$ in. wide, forming on each side a groove near $\frac{3}{16}$ by $\frac{1}{8}$ in. and 6 ft. long. At the present day most glaziers buy their calmes at the warehouse, where they are known as window-leads. The ancient calmes were apparently cast in a mould. Antique calmes are nearly of one uniform width, and much narrower in the "leaf" than modern leads. That this was the case, can be proved not only by the existence of the original leads themselves, but more satisfactorily perhaps by the black lines drawn upon the glass, with which the glass painters were accustomed sometimes to produce the effect of leads without unnecessarily cutting the glass. The process of compressing the modern calmes between rollers to the proper dimensions makes them more rigid than the old leads.

The ordinary leaded casement is still to be found plentifully in cottage windows in the provinces. These are formed of every shape and size, some glazed with rectangular and some with diamond-shaped panes. The calmes in which these are set are often very broad in the leaf, much more so than could be used for ornamental fretwork. Glaziers differ as to the best tool for soldering the calmes, some adhering to the old glaziers' iron without a handle, while others prefer the ordinary copper bit (*see* SOLDERING). The cutting knife, used for dividing the calmes, usually has the form shown at Fig. 218. The blade has an exterior cutting edge where marked, and the top of the handle where shaded is formed of a lump of solder, or lead, which is used for driving home the panes in the calmes, driving a brad or tack, etc. Fig. 219 is the "ladikin," which is a small tool of bone, box, or beech, about 6 in. long, 1 in. in width, and ¾ in. thick, with one end bevelled off for about ½ in. This is used for opening the leaves of the calme as shown.

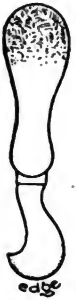

FIG. 218.

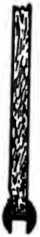

FIG. 219.

The first step in making a lead-light of square panes is to measure the opening and set out on a board or the work-bench in chalk the number of panes decided on; next the glass can be cut, not forgetting to allow for the thickness of the calme, and, this being done, proceed to put the casement together, as shown by Fig. 220.

Tack down to the bench a couple of laths at right angles as shown. Take a length of lead or calme, and putting your foot on one end to hold it steady, stretch it out, by pulling, perfectly straight; now cut a piece of about the depth of the window and place it against the left-hand upright lath, and secure it to the bench by a couple of brads. Next cut another length of the calme the breadth of the casement; open the end of the upright calme at *e* with the ladikin, as shown at Fig. 219, insert the end of the calme last cut, taking care to see that this end is bright, and brad this calme down against the bottom lath at right angles to the former. The calmes are cut with the cutting knife. The first pane of glass is now taken, the ends of the calmes opened out with the ladikin if necessary, the square of glass placed in and tapped up home with the heavy handle of the cutting knife. Having set pane No. 1 cut with the knife a piece of calme of the exact length of the side of the pane, taking care to see that the end is bright; open both sides with the ladikin, then place the end in the lower calme; pane 2 is now placed in this, and carefully tapped home with the handle of the knife. Then the next upright calme is cut and placed; next follows pane 3, and the first row is glazed. The illustration shows but nine panes, three wide and three high; the same process, however, is adopted with a greater number. Take especial care that each pane has been knocked in home, and that the whole row is tight. Now comes the first cross calme. Stretch a length of lead, cut it to the proper length, and open it up with the ladikin. Insert the end of this in the vertical

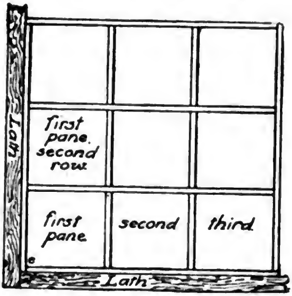

FIG. 220.

calme, and place the ends of the first two upright calmes in it. Now begin another row with the first left-hand pane, follow this with the short lead; then the two following panes till the second row is complete. When all the panes are fixed in and the casement is complete, the top calme is fixed, and then the side one. All is now ready for the soldering. The bit or soldering iron is heated, and the operator takes a strip of fine solder, in his left hand, of an easily fusible kind. He then sprinkles a small quantity of black rosin at the place to be soldered, places the end of the solder strip to the first and applies the heated bit until a good joint is made, and the solder makes a neat little raised circle at the place. This operation is repeated at each joint until all are secured. Some workmen prefer "killed" spirits of salts to rosin for the flux. The bit or iron should not be too hot, and should not be held in contact with the calmes too long. It is important that the ends of the lead be bright, or a good joint cannot be secured. The brads must now be loosened, the light turned over, and the other side be soldered in a similar manner.

Next the "bands" or "ties" have to be fixed. These are small strips of lead, or little bits of copper wire, intended to secure the lights to the "saddle-bars" of the window. The saddle-bars are horizontal bars of small iron rod crossing the window-opening, their ends being set in the stonework or wood, and are intended to support the glass. As many bands should be soldered on as the glazier deems requisite. Copper wire ties are generally used for fretwork. In the rectangular iron frame for opening casements, to which the lead-light is fitted, the smith generally drills small holes all round, and the glazier will require to solder his ties around the lead-light at such places as will correspond with these holes and in such a manner that the ties stand up at right angles to the calme to which they are soldered. They must also be of such size that they will pass through the holes. These ties are put through the holes in the casement frame, cut off flush with the top surface of the iron. A bead of solder is now dropped on the end of the tie, well spread with the bit, and finally spread down into a nice flat round button, by the sudden and momentary application of the thumb, well wetted with saliva.

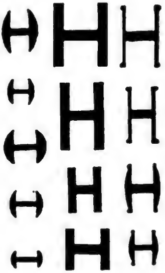

FIG. 221.

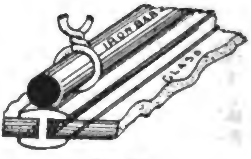

FIG. 222

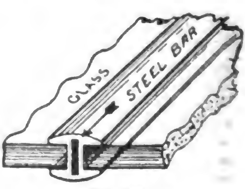

FIG. 223.

The lead-light is now finished all but the "cementing." This process is adopted for several reasons. In the first place it helps to secure the glass in the lead-work, something as putty does in sash-windows, then it keeps the whole window watertight and windtight, etc. Proceed thus: Take an old sash-tool and a little stiff lead-coloured paint, and rub the joints and calmes therewith. Then take a small blacklead brush and a small quantity of whiting, and with this brush rub the paint until it appears all brushed out of the crevices, brush off the whiting, and repeat the process with some lampblack, and brush away until the joints become as lustrous as if blackleaded. Finally clear off, and clean the glass in the usual way.

Different workmen have other ways of cementing the joints. A cement of red and white lead, with a little linseed-oil, and darkened with lampblack, is often preferred as being more lasting than ordinary stiff lead paint, and instead of an intermediate application of whiting (which is scarcely necessary) the dry lampblack is next dusted over and finished off by scrubbing with wood ashes, and a wisp of soft hay. The cement in the corners of the squares is picked out with a pointed piece of wood. Finally polish with a moderately stiff dry brush. The soldered dots are sometimes left bright as they soon tone down with exposure. This work must be done (both sides) while the glazing is flat on the bench. It cannot be properly done when fixed.

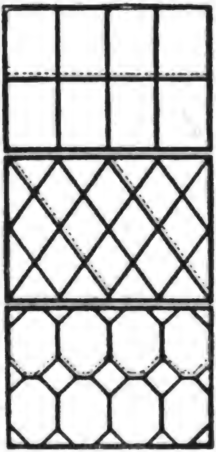
FIG. 224.

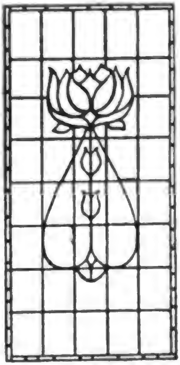
FIG. 225.

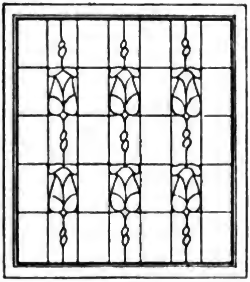
FIG. 226.

The work should be left on the bench for a day or two to dry, if time will admit.

Fig. 221 shows sections of a few of the leads that may be obtained. The variety appearing in the factors' catalogues numbers quite twenty different sections, sizes, and strengths.

Fig. 222 illustrates how the lights are secured to the ordinary saddle-bar, by copper-wire ties, and the illustration is introduced to show a new make of lead or calme to save the use of the bar. It is recognised that the saddle-bar is scarcely ornamental, and it is made much worse by the wire tie with its jagged ends. Fig. 223 illustrates the improvement, this being a lead calme with a steel bar running through it, and Fig. 224 shows, by dotted lines, where stiff calme can be used to give rigidity to the whole. It can be bent to follow any design. The makers are Gibbs and Sons, Charlotte Street, Blackfriars, London. Figs. 225 and 226 are given to illustrate the semi-fretwork character of designs now having a deal of favour. There has been a period of severely plain work and a period of highly decorative design, but for many purposes the intermediate is liked, the plain squares being of rolled or waved clear glass, the ornament in light tints of colours, commonly pale green.

* * *

GLUE, GELATINE, SIZE AND ISINGLASS.

(*See also* CEMENTS, PASTE, ETC.)

THE first three of the above mentioned substances are merely varieties of the same material; in fact, glue and gelatine pass insensibly into each other, while size is identical with gelatine in a softer form. The chief difference is in the degree of purity—as, for instance, gelatine for culinary purposes is always more pure than glue or size. Dr. Ballard describes the materials used in the manufacture of glue as follows:—

Raw Material.—(*a*) "Wet" materials: sheep-pieces or "spetches" from fellmongers; "fleshings" from leather-dressers and tanners; roundings of hides previously limed; the ears of animals; portions of bones to which tendons are attached; clippings of salted and alumed skins used for covering cricket-balls, etc.

(*b*) Dry materials: damaged pelts (Australian); ox feet salted (Australian and South American); calves' pates (German, etc.); horn "sloughs" (the pith or core of horns); clippings and roundings of parchment; glue pieces from fellmongers, leather-dressers, tanners, "pickers" hide works, and trotter-boilers; rabbits' pelts, and shreds from furriers.

Preparation. *Liming.*—Prior to making glue of them, all the soft tissues or materials used require to be limed. Such of them as come to glue-works from the leather-dressers and tanners, and some that come from the trotter-boilers, as well as the dry glue pieces and parchment clippings, have been limed already. But such as have not been limed are soaked first in pits containing milk of lime. After the liming, however, the lime has to be got rid of, or "killed." With this object, the limed materials are well washed with water. This washing is effected in tanks or vats, or in pits. At some works the washing is effected speedily in large barrels so arranged inside as to throw about the materials by revolution of the barrels. In the case of dry glue pieces, however, it is found sufficient to expose the material to the free action of the carbonic acid of the atmosphere, by spreading for a prolonged period on racks in erections, covered, but open at the sides, provided for the purpose. When thus prepared, the materials are ready for boiling. But in some works they are subjected, after being washed, to pressure in a hydraulic press.

Boiling.—The boiling is effected in large open pans or boilers, of which there are usually several together. The pans are each capable of containing several tons of materials. In Young's works at Bermondsey the charge of each pan is 12 tons of fleshings with 1 ton of water, the produce of which is said to be about 25 cwt. of glue. A clear space is kept at the bottom of the pan by means of a false bottom of bars. A clear space in the middle is also kept by means of a vertical framework, which can be taken out and replaced at pleasure. The object of this frame and false bottom is partly to give free space for circulation of liquid during boiling, partly to prevent burning, and partly to assist the straining off of the liquid glue. The materials are boiled either by means of a fire beneath the pan or by means of open steam, or by means of both open and close steam. In some works both means (a fire beneath the pan and steam) are provided for the same pan. The pans are usually raised upon a platform approached by a ladder or steps, and are arranged under a roof or shed open at one or on all sides. When horn "sloughs" are used, it is customary to build them up around the outside of the central framework, before putting in the other materials. During the boiling a man is employed in stirring up the contents of the pan from time to time, and in skimming off the fat which rises to the surface.

When the boiling is completed, the fire is raked out, sufficient time is given for settling and partial cooling, and then the liquid glue is drawn out from the space beneath the false bottom along a wooden channel, in which lumps of alum are laid, to wooden troughs ("coolers") on the ground, and about 1 ft. wide and deep, in which the liquid is left to solidify into a very firm jelly or size.

Solidification.—During the solidification, froth and some fatty matters rise to the surface, and in some works these are skimmed off; in other works they are left to solidify with the glue, and are dealt with in the next process.

This process consists in cutting the contents of the troughs into slices. The solidified material is taken in blocks from the troughs, and cut upon a bench into slices by women. When there is any scum on the surface of the blocks, it is first cut off and put aside to be returned to the pans.

Drying.—The slices thus cut are carried to sheds or erections open on all sides to the air, and are there laid upon nettings to dry spontaneously. When perfectly dry and hard, any mouldiness upon them is scrubbed off with a brush and warm water by women, after which they are laid on a rack to drain and dry, and are finally removed to a chamber heated artificially to between 85° and 120° F. (29° to 49° C.) for a final drying.

The matter left in the pans after boiling is termed "scutch." It is commonly thrown out of the pans in a heap upon the ground, sometimes under the shed where the pans stand, and sometimes in the open air, where it remains until removed to the manure-makers. Sometimes it is sent to the manure-makers in the condition in which it leaves the pan; at other works it is previously deprived of fat, and at others it is made into manure on the premises, without any previous removal of the fat it may contain. The "sloughs," when taken from the pans, are set aside in a separate heap for the use of bone-manure makers.

Size of very different qualities is made at glue-works. Some, destined for rough work, is made of similar materials to ordinary glue, while other varieties, of a fine quality, destined for the manufacture of gelatine and for use in soups, are made with especial care and precautions, and of very carefully selected pieces, such as "calves' pates." It is important that after liming, the lime should be more completely removed than is necessary for glue-making, and for this purpose the pieces are first treated with a weak solution of hydrochloric acid. The boiling is effected in a similar manner to that of glue, except that free steam is more frequently used for heating the contents of the pans than in glue-making. The liquid size is either run out into little tubs for sale, or into a large vat, out of which it is taken and broken up for packing in tubs. The finest kinds of size for esculent purposes are made into blocks. Steam-jacketed pans are used in making such kinds. Some of the fine kinds of size made at ordinary glue-works go to the paper-makers. Size is sometimes made by first acting upon horn piths with hydrochloric acid, and then boiling them with water.

According to another account, the liming process consists in steeping for some weeks in a pit with lime-water. The object of it is to remove any blood or flesh adhering to the skin, and to form a soap with any fatty matters present. During the boiling, test-samples of the liquor are taken from the boiler at intervals and examined as to their consistence; when a sample in cooling forms a stiff jelly, the charge is ready to be drawn off. The first boiling generally occupies about 8 hours; and when a charge of liquor has been withdrawn, the boiler is replenished with fresh water, and the boiling is continued. The complete exhaustion of the gelatinous matter is only effected after 6 boilings, occupying about 48 hours. The successive charges deepen in colour till the last. The boiling must not be protracted beyond the point necessary for yielding a stiff gelatinous solution, otherwise the long continued heat will have the effect of destroying the congealing power of the gelatine. Before passing to the coolers, the liquor is kept for some time in "settling-backs" in a fluid condition, to allow mechanical impurities to settle out. The coolers measure 6 ft. long, 2 ft. wide, and 1 ft. deep. When the glue has set, a little water is run over its surface to facilitate its being cut into slices about 1 in. thick. The drying is the most delicate and difficult operation, and the characters of our climate have much to do with the inferior quality of the glue produced here as compared with that made in France. Simple air-drying affords the best article, but the plastic masses must be protected from rain, frost, and strong dry heat—hence spring and autumn are the most favourable seasons, when the drying may be effected in 12 to 18 days. The cutting of the glue into thin slices is performed by means of a wooden box with slits in it at suitable intervals, and a brass wire attached to a bow. The square blocks from the coolers are placed in these boxes, and thus held securely while being operated upon by the wire. The slices are spread on nets attached to wooden frames, which are placed in piles in a field, with proper intervals for the admission of air, and each pile is roofed over for protection from the weather. The slices are turned 2 or 3 times a day, and for this purpose the roof is lifted off the pile, and the uppermost frame is placed on the ground. The slices are turned one by one, and then the second frame is lifted off and set on the first, and so on till a new pile is formed, when the roof is replaced.

During the drying, the glue is more likely to receive injury than at any other period. In very warm weather the cakes are liable to become so soft as to lose all shape and unite with the frames, or they may even melt entirely and flow away. A thunderstorm sometimes prevents a whole field of glue from hardening, while a thick fog may make it all mouldy. A brisk drying wind may harden it so suddenly as to render it unsightly and unfit for the market. A hard frost, by freezing the water in the glue, may cause it to crack in all directions, rendering remelting necessary. Thus the manufacture has many vicissitudes to suffer, and can only be profitably and conveniently carried on in temperate and equable weather. The drying, however, is not entirely finished in the open air. When the glue is about three parts dry, it is removed to lofts, where in the course of some weeks or months the hardening is completed. But as the surfaces of the cakes become mouldy and soiled, it is at length necessary to scour them with a scrubbing-brush and hot water, and set them up to drain. They are then finally dried off in a stove-room at an elevated temperature, which, when they are once solid, only serves to harden and improve them.

To obviate the ill consequences of extremes of temperature and changes of weather in the manufacture of glue, Fleck proposes desiccation in the presence of certain salts. When a solution of gelatine is treated with ammonia sulphate, magnesia sulphate, or Glauber's salts, the gelatine contracts into an elastic mass no longer susceptible of fermentation, and containing but 18 per cent. of water. Mixed with fresh glue, which contains 80 or 90 per cent. of water, it makes a glue of medium consistency, easily soluble, containing 53·4 per cent. of water, and resembling that prepared for cloth-workers' use by Stalling, of Dresden. Undried glue contains 72 to 93 per cent. of water; glue carefully dried in the air, 12 to 15 per cent. only. The problem is therefore to eliminate 60 to 80 per cent. of the water as speedily as possible without injury to the quality of the glue. If the bottom of a flat vessel be covered with a layer of the above-mentioned salts, and the sheet of glue laid thereon between 2 damp cloths, the salts quickly deliquesce. At the end of 12 or 18 hours, this ceases, and the sheets will be found to contain 25 per cent. of water only. Desiccation can thus be effected without the risks of melting and putrefaction in summer or congelation in winter. The glue gains rather than loses in respect of adhesive powers. It, however, retains 3 to 6 per cent. of the salts employed, which, although they do not impair its quality, give it a dull appearance, like Russian glue. The salts can be dried by evaporation, and used over again. ('Mon. Indust. Belge.')

It appears from the observations of Schattenmann, a glue-maker, that fresh glue dries much more readily than glue that has been once or twice melted; and that dry glue steeped in cold water absorbs different quantities of water according to the quality of the glue; and the proportion of water so absorbed may be used as test of the quality of the glue.

It seems that fresh glue contains water of composition, or water more intimately united with the glue than water mixed with it in the process of melting, which admits of being readily disengaged by evaporation. The combined water of dry glue disappears in the course of successive meltings and solidifications to which glue is subjected. Glue in thin plates is usually of better quality than thick ones, even when made with the same kind of gelatine, because the thin plates admit of a more complete drying than the thick. In applying Schattenmann's test, dry glue is immersed for 24 hours in water at the temperature of about 60° F. (15½° C.). A jelly will thus be formed, the qualities of which will fairly represent those of the glue. For example: the finest ordinary glue, or that made from white bones absorbs 12 times its weight of water in 24 hours, so that a plate weighing 3 gr. produces 39 gr. of fine elastic jelly. Glue from dark bones absorbs 9 times its weight of water, and produces not quite so fine a jelly. The ordinary glue made from animal refuse, absorbs 5 times its weight of water, producing a soft brown jelly, without elasticity and consistence, and falling to pieces when handled. The common glue absorbs 3½ times its weight of water.

Well-dried glue is much less hygrometric than badly-made glues or those made of inferior materials. The latter are liable to putrefaction. The water of composition seems to be injurious to the strength of glue, which increases in proportion to its dryness.

Testing Glues.—Following are some observations of the chemical characters of commercial glue not generally known. Analyses of two samples of white glue of the best grade yielded the following results :—

	"No. 1 extra C" glue.	Frozen glue
Moisture (loss of weight at 212° F.)	16·70	16·28
Gelatine, with a little animal fibre and fats	79·85	80·42
Carbonate of lime	1·42	1·33
Sulphate of lime	0·41	0·34
Phosphate of magnesia	0·35	0·31
Alkaline salts	0·17	0·12
Silica, oxide of iron, etc.	0·09	0·08
Oxide of zinc	1·01	1·12
Total	100·00	100·00

Analyses of 10 more samples of frozen and sheet glue, of common grades and from different makers, showed the proportion of water contained in them to vary from 14 to 18 per cent., averaging 17 per cent. And the proportion of ash or mineral matter varied from 3 to 6 per cent,, averaging rather less than 4 per cent. Two of these samples contained about 1 per cent. of white zinc, and two of them contained sulphate of lime. Analyses of 2 samples of commercial gelatine averaged 16½ per cent. of water, and 2·56 and 3·11 per cent. of ash respectively. There was no oxide of zinc or sulphate of lime in these gelatines. The presence of so much water was quite unexpected; and as the quantity is nearly the same in fresh and in seasoned specimens, it is not a makeweight. although steam is very freely used in the rooms where glue is packed by the manufacturers. The carbonate of lime comes from the quicklime used for cleaning and preserving the animal matter, or glue stock, while the sulphate of lime is formed by the addition of small quantities of sulphuric acid during the process of manufacture, to neutralize the lime that is carried forward by the solutions of glue. The oxide of zinc is said to be added to prevent souring, or the acidity caused by decomposition, and it also improves the colour of the glue; but it is not generally used, as these analyses indicate. The impure glues, or those containing the most mineral matter, became almost insoluble after they had been broken into small pieces and heated in a hot-air bath (copper oven) at 212° F. (100° C.) for 2 or 3 hours, until they cease to lose weight; they then soften and become dough-like, but do not dissolve when boiled in water for some time. The purer gelatines were not so much injured, and one specimen, containing only 2·56 per cent. of ash, was not materially affected by this thorough drying. The solid sheet glue, while drying in this way, tumefied and became very porous; the frozen glue did not alter in structure. The conclusion drawn from these experiments was that the excess of lime combines with the gelatine, and perhaps with the extraneous animal matters of the glue, at the high temperature, forming a compound like lime-soap, as the whole quantity of lime is retained in the insoluble portion left after boiling the dried glue in water. Such an explanation accounts for the difference noticed in the effect of drying upon gelatine and common glue.

In the selection of glue, the testing of it, so as to form some estimate of its adhesive qualities, is a matter of first importance. All glue in the cake is subject to be influenced by the moistness or dryness of the atmosphere, becoming soft in damp weather and crisp in dry weather, but different kinds are differently affected, and hence it is better to purchase in dry weather, as that which is then soft is not of as good quality as that which is crisp; and it should be borne in mind also, when purchasing, that the most transparent is generally the best. It is always advisable, before purchasing, to submit to experiment a sample of the article offered. To do this, take a cake of glue, place it in a pan, and cover it with water; when, after some hours, if it be good glue, it will swell but not dissolve, while, if bad, it will partly, if not wholly, dissolve in the water. Another test is this: after being dissolved by means of heat, that glue is best which seems most cohesive, or which is capable of being drawn out into thin filaments or strings, and does not drop from the brush or glue-stick as water or oil would, but rather extends itself in threads as it falls from the brush or stick; and if the glue possesses the requisite properties, this will always be found to be the case.

Gelatine.—In the preparation of gelatine, during the boiling of bones for the removal of the fat, a portion of the cartilage enters into solution in the water. At ordinary bone-boiling establishments, the residual liquor, though containing more or less gelatine, is run off into the drains; but in establishments where size is made, the gelatinous liquor obtained by the prolonged boiling is drawn off by a tap from the lower part of the boiler, and is subsequently boiled down to the required consistence, either in the same or in another similar boiler, from which it is usually drawn off into cases for sale. A modification of this plan consists in crushing the bones, treating them with steam at high pressure, adding a proportion (2 per cent.) of hydrochloric acid to the semi-gelatinous mass thus formed, and re-boiling. The fat separates and floats in the liquor, to be easily collected and purified by being treated first with boiling water and a very small quantity of caustic soda, next with animal charcoal, and finally filtered.

The osseous cartilage may be removed from bones by suspending them in weak nitric or hydrochloric acid, (1 part acid to 9 parts water) at 50° F. (10° C.). The acid causes an effervescence, by acting on the carbonate of lime, and dissolves out the whole of that and the other earthy constituents without affecting the cartilage, which, while retaining the form of the bone, soon becomes soft and translucent. It is then washed in 2 or 3 changes of cold water, to remove all traces of acidity. It shrinks and darkens on drying, becoming hard and strong, but somewhat brittle, and losing none of its transparency. It now forms gelatine. It has been proposed to obtain gelatine from bones, etc., by means of benzine and other hydrocarbons. Sometimes it is found advisable to treat the material with lime before adding the hydrocarbon, but only rarely. After the bones have remained for a considerable time under the influence of the hydrocarbon, the fatty matters are dissolved, and the pure gelatine is found at the bottom of the vessel. The 2 products are thus easily separated, in order to be treated in the usual way, and the hydrocarbons are recovered by evaporating with steam and condensing.

German plan for preparing gelatine from bones: The bones are exposed to the sun and air for about 6 weeks, and in dry weather are moistened several times daily with water. Quantities of 10 to 15 cwt. are put into vats, and soaked with a solution of hydrochloric acid at 4° (? Beaumé), which is drawn off when saturated, and replaced by a fresh solution, repeating till the bones are softened. These are washed in fresh water, and placed for 14 days in a solution containing a small amount of lime, then taken out and thoroughly rewashed in fresh water, and laid out upon large plates to dry in the air. The product at this stage is raw gelatine. About 300 lb. of this is laid in running water for 24 hours, which makes it soft and easily broken up; it is then left for several days exposed to the open air, after which it is put into an immense kettle with 40 gal. river water; a fire is made, and it is slowly cooked, the mixture being stirred every ½ hour, and 4 oz. alum added, which helps to liberate the fatty particles, and thus materially to purify the gelatine. After cooking for 8 to 18 hours, according to the state of the mass (which may be tested by filtering some through a linen cloth, from which it should come clear and free from all impurities), the whole is put into a vat containing 3 gal. fresh water, acidulated with sulphuric acid. It is stirred, 2 qt. acetic acid are added, and the mass is left to stand for 1 hour, when it is again filtered through linen cloth, and put into wooden vessels, where it gradually attains a solid state. Before becoming thoroughly hard, it is cut by machine into thin sheets, and laid out to dry in an airy and dry spot under an awning. The very best brand of gelatine is said to be made in this way. Should it be desired to produce coloured gelatine, the following modification is needed. On completion of the last filtration through linen cloth, a small quantity of gall is added, and then the required colouring matter. The most common colour is carmine, dissolved in *aqua ammoniæ*, and stirred into the mass. Aniline colours may also be used. The proportions are generally 1 oz. colouring matter to 4 lb. liquid gelatine, the former being first thoroughly cleaned by repeated straining through linen cloth, then added to the diluted gelatine, and the whole well mixed while warm and poured out on large frames or sheets of glass placed in a cool, dry, airy place. The sheets are taken off when dry, or just before, if they are to be stamped with patterns.

In the method of manufacture known as Rice's, the bones are placed in dilute phosphoric acid, by which the earthy matters are dissolved and removed from the cartilage, which latter can be turned into gelatine by any ordinary process. The acid is recovered from the earthy matter for re-use in the following way. About ⅔ or more of the solution of acid phosphate of lime is submitted to the action of sulphurous or sulphuric acid, which precipitates the lime as sulphite, or sulphate, either being easily removed, and leaving the acid or acid phosphate (according to the amount of acid used) in an available condition for further use on fresh bones. By extracting the phosphates originally held in the bone, this process yields an actual surplus of phosphoric acid, so that it is claimed that almost 50 per cent. can be gained on each treatment. The residues are used for manure. The cost of production is said to be greatly reduced by this plan. Phosphoric acid alone is found to be best; but it may also be used in conjunction with other acids, in such proportions that the mixture will dissolve and remove all earthy matters.

Cox's process for making "sparkling" gelatine is as follows. The hide and skin pieces (preferably the shoulders and cheeks of ox-hides) are washed in water, chopped fine by machinery, and reduced to pulp in a mill; this pulp is pressed between rollers, mixed with water, and submitted to a heat of 150° to 212° F. (65½° to 100° C.), whereby the gelatine is extracted. To obtain a very pure quality, liquid gelatine is mixed with a small quantity of ox-blood at 160° to 170° F. (71° to 77° C.), and further heated; the albumen of the blood coagulates and forms a scum, which can be removed when the heat is withdrawn, leaving the purer liquor to settle, ready for running into coolers to harden and dry. The evaporation is conducted *in vacuo*, to reduce the temperature and duration of the operation.

Heuze obtains gelatine of good quality from even inferior sources, such as the substances obtained during the manufacture of neat's-foot oil. The gelatine from this source is very dark, and hence has only a limited sale at the low rate of about 2*d*. per lb. By digesting for 3 hours at a pressure of 3 atmospheres, pouring off the resulting ammoniacal solution of gelatine, separating the supernatant oil, and evaporating, a black friable gelatine results. Attempts to bleach this by sulphurous acid, or a sulphite and hydrochloric acid, gave unsatisfactory results. If the digestion, however, be continued for only 1 hour, and the liquid be then run off, a second digestion for an hour following with fresh water, and after pouring off the second liquor, a third for another hour, a much better result is obtained, the liquids resulting being almost perfectly decolorised by treament with 4 per cent. of charcoal mixture, consisting of 100 parts wood charcoal, 25 parts animal charcoal. The gelatine thus obtained can be used for food, as it has no smell, and has only a slight yellow tint when seen in large masses. ('Dingler's Polytech. Jl.')

Nelson's gelatine is extracted by steam heat from hide pieces which have been submitted to the bleaching action of sulphurous acid. The strained and purified article is spread in a thin layer on a marble slab till it partially solidifies; next it is cut up and washed to free it from all traces of the acid; again dissolved at the lowest possible temperature; and finally re-solidified and dried in thin sheets on nets.

Bone gelatine differs materially from skin gelatine, while the product of one animal may not be the same as that from another. Some gelatines—the inferior ones—dissolve at a low temperature, and others, again, set with extreme difficulty. It should be observed, says Dr. Eder, that good gelatine, when dissolved, not only colours water very slightly, but gives an almost colourless jelly. Dr. Eder suggests two practical ways of ascertaining the quality of gelatine. The first is—although it may not hold good throughout—to see how much water the material is capable of absorbing, the more water taken up the better being the gelatine. To find out this, a piece of gelatine should be accurately weighed, and then permitted to soak for 24 hours in water at 59° F. (15° C.). The examination of a series of samples in this way will soon teach something about them. Another test is to find out the weight necessary to crush a gelatine jelly. Thus, if you have half-a-dozen samples to examine, solutions are in the first place prepared, 5 grm. gelatine being dissolved in 45 c.c. water. Half-a-dozen beakers or glass vessels of precisely the same diameter are obtained, and the solutions placed therein to set, at a temperature of 59° F. (15° C.). All gelatines should set at this temperature; if they do not, says Dr. Eder, they may be put on one side as unfit for photographic use. When set, there is lowered upon each jelly a little apparatus, consisting of a piece of tin shaped like a watch-glass, to the centre of which a wire is attached. The convex face touches the gelatine, and when it is weighted sufficiently it breaks through. At the upper end of the wire is a funnel, and to weight the apparatus small shot is dropped into the funnel. The weight of the apparatus should of course be in all cases the same, and this equality is soon brought about by adding shot to make up weight. The jelly which proves to be the firmest may be regarded as the best gelatine. An arrangement for steadying the wire is necessary, and this may be effected by covering the mouth of the beaker with a metallic plate having an orifice through which the wire passes. The moulded metal plate touching the gelatine need not be more than ½ in. in diameter, while such is the toughness of the gelatine in some cases that 3 lb. of shot are occasionally necessary before the apparatus tears the film. The tougher the gelatine the better it is. The better kinds of gelatine are all found to dissolve pretty well at the same temperature, but in the case of gelatine of inferior quality this dissolves in water at a very low temperature.

Glue.—It is not at all necessary, remarks Dr. Ballard that glue-works should be a nuisance to the neighbourhoods in which they are situated. As respects the materials brought into the works: the moist materials, if not to be used immediately, should be at once placed in weak or old lime-pits or tanks, and in the event of an unexpected receipt of limed fleshings or pieces beyond the manufacturer's requirements for some length of time it would be better (if the weather permits) to dry them off for future use than to leave them in loose heaps in the yard, especially in an open yard, and not under cover. At Turney's, in Stourbridge, moist fleshings are carefully stacked for future use. Before stacking the pieces in the winter, they are washed through a milk of lime in a washing machine. They are then stacked (about 100 tons in a heap) as closely as possible, so as to exclude the air. The stacking requires care. If any hollow places are left, the pieces become bad very soon. They are best put in large heaps 6 or 8 ft. high, since their own weight presses them down, and in a few days the heap becomes quite solid. If at any time the sides or top of the heap become tainted, a layer of about 6 in. has to be cut off and re-limed. The practice adopted by some manufacturers, of preserving their fleshings immersed in lime liquor in sunken pits is more injurious. An excess of lime has to be guarded against, since it destroys both the glue and the grease. The pieces which have been in lime for a long time yield much less than those boiled while fresh. Properly stacked pieces may, without injury, be preserved throughout the winter, or even for 12 months. Bevington, of Bermondsey, another very large manufacturer, agrees with Turney. He says that in the event of a glue manufacturer being from any cause overstocked with "wet" goods, and being unable to use them fast enough, the best method is, broadly, to dry them; but this course is often impracticable for several reasons, such as (*a*) because, if the weather be bad for glue, it is at the same time bad for drying fleshings; (*b*) because of the want of proper appliances and space; and (*c*) because it depreciates the value of the goods, as when once dried they cannot be used for the same purposes as wet goods, e.g. for size-making. The method of drying being put out of the question, the next best thing is to stack them; and, if this be done properly, they are but very little injured by keeping for several months, and are no nuisance whatever. The way to do this is to place on a well-drained spot a layer of the fleshings a few inches thick, the size of the proposed stack, and then to throw over it a liberal supply of milk of lime, then put on another layer of fleshings, and treat it in the same way with milk of lime; and so on until all the goods are stacked. All this would appear to be to the interest of the manufacturer, and would certainly conduce to the comfort of his neighbours.

No good reason has been assigned for the universal practice of permitting the vapours from the boiling pans to diffuse into the atmosphere outside the sheds. There can be no more reason why this should be, than it should be permitted to occur in the works of soap-boilers, trotter-boilers, etc., where methods of preventing the escape of offensive vapours from the works are in use at some establishments. Two methods of dealing with them may be suggested. One is the partial enclosure of the sheds in which the pans are situated, with the use of a fan to draw off the vapours from the interior of the building to a tall chimney shaft; and the other is the fitting of the pan with a cover provided with such a hinged lid as shall permit of the workman stirring the contents and skimming off the fat; conjoined with a flue carrying the vapours into a fire so arranged as to produce a down-draught into the pan. Dr. Ballard observed during his visits to glue-works that the vapour from the pans was least offensive when they were heated by steam, either by jacketing the pans or by the use of open steam.

The accumulation of "scutch" in heaps in the glue-yard, and its retention there, is an instance of traditional trade slovenliness which ought at once to be put a stop to. There can be no excuse whatever for the continuance of this source of nuisance at any works. The "scutch" ought either to be put at once into hogsheads and fastened down for removal; or, until it is removed in covered carts or barges, or in hogsheads, it should be deposited neatly in an appropriate chamber or shed, and not be allowed to remain even there above a day or two, especially in warm or muggy weather. In Freeman Wright's works, one of the best conducted, a well-ventilated shed, open on one side and provided with a raised platform, on which the scutch may be laid, and a screen to hide it from view is found to be better than a closed-in shed or chamber. The roof and walls of such a shed, however, should be whitened outside for coolness in the summer time, and be kept scrupulously clean and limewhited inside. At Nickol's, Joppa, Leeds, and at Clark and Thackray's, Newlay, Leeds, the "scutch" is dealt with immediately on its removal from the pans, for the extraction of the fat it contains and the conversion of the "scutch" into a cake which is almost devoid of odour. While preventing annoyance to neighbours, the proprietors must find the process profitable. On its removal from the pans, the "scutch" is thrown into a tank of water, and some sulphuric acid being added, free steam is admitted. The fat which rises is taken off, and the residue is put into coarse bags and subjected to pressure in a well-closed hydraulic press, into which more steam is thrown. The liquid matters pressed out run into a tank, where more fat rises and is collected. The cake is stored on the premises without giving offence, until it is convenient to have it removed. Such dry cake should be stored under cover.

The general untidiness and superficial filthiness of glue-yards is only another instance of slovenliness showing the conservative power which attaches to ancient tradition. It need not be so, and in the interest of the manufacturer would be better not so. All parts of the premises should be firmly and evenly paved with appropriate materials, and duly sloped to good channelling, and well drained throughout. No litter of any kind is necessary, or should be permitted. The surface should be kept constantly swept up, and washed down with water from time to time. Every scrap of gelatinous glue should be gathered into proper receptacles for return to the pans. Leakages from channels and troughs should be immediately made good. The interior and edges of the pans, and everything about them should be kept clean and free from deposits, and tidiness of working be maintained, as it readily may be, by due regulations for the establishment. (Dr. Ballard.)

The glue made at the present time is, as a rule, much superior to that of a quarter of a century ago—that is, there is more of a high grade to be had, and prices are lower than they were, quality for quality. The little difference in the price of the best and that of any lower grade that could be used at all is so slight that every man can afford to use the best. Next to the quality of the glue comes the preparation, and it is an easy matter to render the best glue valueless. Glue as now sold comes in broken pieces, generally very thin; and the best, when held to the light, is semi-transparent, although some fine glue is sold in squares that are $\frac{1}{8}$ in., more or less, in thickness. The other form is the ground glue. Soaking glue before melting requires care, as the best can be weakened by allowing it to soak until it begins to show decay. This condition is easily detected by the smell. The pure glues do not emit objectionable smells unless decomposition begins, and it is this decomposition that reduces the adhesive properties of the glue. For this reason soaking should not be continued any longer than is necessary to soften the glue without reducing it to a pulpy mass. The purity of the best grades is such that even if soaked in cold water, six to eight hours is sufficient; if tepid water is used, six hours is the maximum time necessary. All who have given the matter close attention know that there is a marked difference in the amount of water that will be absorbed by different makes of glue when soaking, and also the amount necessary to dilute it to a working consistency. It follows, therefore, that the best results can be obtained by using one brand, if tests prove it to be of high quality.

After the glue is soaked, it should be melted as quickly as possible in the double glue kettle; none other is fit for use. The interior kettle should be of copper or the modern enamelled ware; the iron kettle discolours the glue, and the effect of the action of the iron upon the melted glue causes it to rot. This is the case particularly when the glue is reheated two or three times. In the copper or enamelled kettles no change of colour is noticeable until the glue begins to decompose. The glue kettle should have a good cover, one that will keep out dust and dirt, and it is a good plan to have a pocket as well in which to keep the brush when not in use; leaving brushes in the hot glue and allowing them to remain in until the glue gets cold leads to the accumulation of dirt, besides doing injury to the brush and eventually loosening the hairs. If ground glue is used, soaking as generally understood is unnecessary; but it is well to wet the powder with tepid water, and allow it to stand half an hour or so before melting. In hot weather, it is a good plan to put in a few drops of an essential oil to retard decomposition. This is particularly desirable when the melted glue is poured out in shallow pans to await further use, instead of its being allowed to stand and simmer over the fire for a day or more. This cooled glue is dissolved quickly by heat, and retains its consistency, whereas glue that is allowed to remain over the fire for several hours thickens through the evaporation of the water, and must be thinned before it can be used; and it happens too often that cold water is poured in, or that hot water out of the iron kettle is employed, both of which tend to injure the glue. We omitted to state, when referring to soaking, that pure water should be used. Soft water is best, next to that is condensed water; the most objectionable is hard well-water. This suggestion as to the selection of water should not be treated lightly, as the water exerts a marked influence upon the glue, both as to tenacity and durability. ('The Hub.')

Liquid Glue.—(1) This is made by soaking glue first in cold water, then adding the necessary quantity of warm water and heating in a water bath until the glue is melted. Nitric acid is then added slowly, stirring all the time. The proportions vary somewhat as follows. (*a*) 50 parts glue, 50 to 60 parts water, 3 parts commercial nitric acid (36° B.). (*b*) 50 parts glue, 100 parts water, 6 parts nitric acid (36° B.). (*c*) 50 parts glue, 70 parts water, 8 parts nitric acid (36° B.). Do not make in an iron vessel, as the acid attacks this and will discolour the glue.

(2) Dissolve 1 part starch in water. Dissolve separately 1 part glue in water, in a water-bath. When the glue is ready, remove from the fire and add 1 part turpentine followed by the starch solution. Put back on the fire, in the water-bath, mix well together, and add water if required to make more fluid.

(3) Make ordinary glue sufficient to fill a bottle two-thirds full, then fill up with common whisky. This has the good quality of keeping for years. It may go solid in cold weather, but is easily made fluid by standing the bottle in warm water. The bottle must be kept corked or the spirit will evaporate.

(4) Dissolve ¼ lb. glue in ½ lb. nitric ether. This is a very tenacious adhesive, and will resist damp.

(5) 4 oz. transparent glue, 4 oz. diluted nitric acid, ¾ gr. methylated spirit, ½ drm. benzoic acid. Cut the glue into very small pieces and put it into a wide-mouthed bottle; add nitric acid, and stir often until dissolved. Dissolve the benzoic acid in the methylated spirit, and add to the above. For white, make use of transparent white gelatine (second quality) in sheets.

Cut it up and proceed as in the above case. The glue should be kept well corked up.

(6) One pint of commercial acetic acid, 3*d*., and ½ lb. of best glue. Use two pickle bottles : put the glue and acid in one, and after a few hours it is dissolved. When using pour off the supernatant acid into the other bottle. This glue will stick china glass, etc., and a good mountant for photographs. It is of a proper consistency when it will not wet through the paper.

(7) Russian glue, 5 oz. ; methylated spirit, 5 oz. ; water, 5 oz. Dissolve the glue in the water by the aid of a water-bath, then add the spirit. The above recipe dries very quickly and is reliable.

(8) Take a wide-mouthed bottle and dissolve in it 8 oz. best glue in half-pint water, by setting it in a vessel of water and heating until dissolved. Then add slowly 2½ oz. strong aqua fortis (nitric acid) 36° Baumé, stirring all the time. Effervescence takes place under generation of nitrous gas. When all the acid has been added the liquid is allowed to cool. Keep it well corked and it will be ready for use at any moment. This preparation does not gelatinise, nor undergo putrefaction nor fermentation.

(9) Take one quart soft water, 2 lb. best pale glue. Dissolve in a covered vessel by the heat of a water bath. After cooling, add with caution 7 oz. nitric acid ; when cold, bottle off.

(10) Macerate for several hours 3 parts good glue in fragments in 8 parts of water, adding half-pint hydrochloric acid and ¾ pint sulphate of zinc, exposing the whole from 10 to 12 hrs. to a temperature of 178° to 189° Fahr. The mixture is permanent, remains liquid, and forms an excellent paste.

Marine Glue.—(1) Glue 12 parts, water to dissolve. Yellow resin 3 parts, melt and add 4 parts turpentine, and mix.

(2) 17 parts glue, 23 parts water, 2 parts litharge, 6 parts acetic acid, 8 parts raw linseed-oil, 6 parts sulphate of lead. Soak the glue for some hours in cold water, then melt in the ordinary way ; while hot stir in the acid. Heat the oil and litharge separately for 10 minutes and then stir in the hot glue ; finally stir in the sulphate of lead.

(3) Dissolve 1 part india-rubber in 12 parts coal-tar naphtha ; add 20 parts shellac, and heat the whole, stirring well, until of proper consistency. Apply hot. It is very adhesive under water. Use care in the heating as naphtha is very inflammable. Steam heat is best, and a closed pan to prevent evaporation.

Glue for Veneering and Inlaying.—Good light coloured clear glue is dissolved in water, and to each pint is added ½ gill best vinegar and ½ oz. isinglass.

Glue to Resist Scalding Water.—Dissolve 14 lb. glue in water. Dissolve 1¼ lb. of alum and 1 lb. bichromate of potash in water. Mix the two just before using.

Waterproof Rubber-Glue.—Dissolve ¾ lb. shellac and ¼ lb. india-rubber, each separately, in ether free from alcohol. This should be done in closed vessels or bottles, without heat, as the ether is very volatile. When both are melted mix together, and keep air-tight.

Fireproof Glue.—Soak 1 part of glue or gelatine in 8 parts of raw linseed-oil for a day, then gently heat the oil until the glue is melted. Then stir in 2 parts of quicklime. Spread out in layers to dry in the shade. For use heat in a glue pot in the ordinary way.

Starch Glue.—Put together in a pan, 3 parts water, ½ lb. pure nitric acid, and 2½ lb. potato starch. Keep in a warm place for 24 hours, stirring occasionally. Then boil until it becomes thick. Dilute with water if required, and filter through a cloth.

Glucotin. (Cement for broken articles. *See also* CEMENTS.)—4 oz. Russian isinglass, 3 oz. gelatine, 24 oz. water, 4 oz. strong acetic acid. Put the isinglass and gelatine in the cold water for 2 hours, then melt by heat in a water bath. Add the acid and evaporate down to 18 oz., then stir in 2 oz. spirits of wine. Bottle while it is fluid. For use the bottle is stood in hot water until the cement is fluid, then a little is applied to the broken surfaces which are afterwards pressed together and allowed to dry firm.

Mouth Glue.—Any good glue dissolved in a small quantity of water. Add just a small quantity of Demerara sugar and an essence. Pour into oiled moulds. For use apply the tongue and rub the wetted part on to the paper that is to be stuck.

Portable, for Draughtsmen. Glue 5 oz., sugar 2 oz., water 8 oz. Melt in water-bath, cast in moulds, and dissolve for use in warm water.

For Bank-Notes.—Fine glue or gelatine, 1 lb., dissolved in water, and the water evaporated until nearly expelled. Add ½ lb. brown sugar, and pour in moulds.

Elastic.—Dissolve glue in a water-bath, evaporate to a thick fluid, and add an equal weight of glycerine. Cool on a slab.

Heat and Moisture Proof.—Linseed-oil 4 oz., 1 handful of quicklime; boil to good thickness, and cool. It will become very hard, but it is as easily dissolved as common glue.

Waterproof, Simple. — Common glue 1 lb., boiled in 2 qt. skimmed milk.

Isinglass.—Isinglass, or fish glue, in its raw state, is the "sound," "maw," or swimming-bladder of various kinds of fish. The sounds undergo no other preparation than careful drying, but in the drying they are differently treated and made up, so that the isinglass comes into commerce under the names of "leaf," "staple," "book," "pipe," "lump," "honeycomb" and other designations, according to its form. The finest isinglass, which comes from Russia, is prepared by cutting open the sounds, steeping them in water till the outer membrane separates from the inner, then washing the latter, and exposing it to dry in the air. Russian isinglass is obtained from several species of sturgeon (*Acipenser*), found in the Volga and other tributaries of the Caspian Sea, in the Black Sea, and in the Arctic Ocean. Brazilian isinglass, obtained from Brazil and Guiana, is the produce of a large fish, *Silurus parkerii*, and probably some other species. Manila and East Indian isinglass is yielded by species of fish not yet satisfactorily determined. The sounds of the common cod, the hake, and other *Gadidæ*, are also used as a kind of isinglass.

The best quality of American isinglass is made from the sounds of the hake. The crude material is collected during the summer and autumn, coming from Maine, New Brunswick, Nova Scotia, and Prince Edward's Island. The conversion of the crude material into the mercantile article takes place in winter. A low temperature is necessary in order to turn out by machinery the fine ribbons of isinglass, and ice-water passes through the rolls. Besides the use of isinglass for fining beer, etc., it is employed as a dressing or glaze for straw goods in the United States. ('Scient. Amer.')

The manufacture of isinglass is carried on to a considerable extent in India, principally from the air-vessels of several varieties of acanthopterygian fishes, and particularly different kinds of perch, as well as from other fish. ('Nature.')

Seaweed Isinglass.—A very interesting product, called *kanten*, or vegetable isinglass—a species of gelose derived from either of the seaweeds *Gelidium corneum* or *Plocaria lichenoides*—is made in China and Japan, and exported to Europe in flat and moulded tablets and in bundles of strips. It is known in Cochin China as *hai thao*, and is used in France in several industries, especially in the preparation of goldbeaters' skin, and for rendering tissues impermeable. It is soluble in boiling water only, of which it takes up about 500 times its weight. It is manufactured as follows. The seaweed, called by the native name of *tengusa*, is carefully washed and afterwards boiled, so as to form a gluish decoction, which is strained off and put into square boxes. When cool, it forms a stiff jelly, which can easily be divided into squares a foot in length. The manner in which the surplus water is removed is very ingenious. The jelly prisms are exposed in the open air during a cold night, and allowed to freeze. During the day the sun melts the water, which runs off, leaving behind what one might term the skeleton of white horny substance, which is extremely light and easily dissolved in water; when cooled, it again forms a stiff jelly. This article can be applied to many purposes—for culinary uses, for making bonbons and jellies, for clarifying liquids as a substitute for animal isinglass, for making moulds used by the plaster of Paris workers, for hardening the same materials—in short, as a substitute for all kinds of gelatines, over which it has the advantage of producing a firmer jelly. Another seaweed much used for industrial purposes is the *fu*, resembling carrageen or Irish moss, and applied to similar uses, such, for instance, as the sizing of the warp of silk goods. Recently the manufacture of an isinglass of this kind has sprung up in France, being made from the seaweeds found on the coast of that country. In its crude state it is a yellowish gelatine, but, after repeated experiments under the auspices of the Industrial Society of Rouen, it has been successfully converted into what bids fair to prove the best sizing for cotton cloth known, and will probably entirely supersede the Asiatic product. Macerated in water for 12 hours, boiled for 15 minutes, and stirred till it becomes cold, the article gives a clear solution, which, as it does not again become a jelly, can be laid in its cold state upon any textile fabric and be left to dry. One invaluable property it possesses is that of defying at common temperatures damp and mildew; and it is therefore being applied to give a lustre not only to French prints and muslins but also to woollens and silks. In China, the first quality of the seaweed isinglass is used in a number of industries, especially in stiffening light and transparent gauzes, and the fine silk which is used for making fans, screens, hangings, etc. It is on these stuffs, so well stiffened that the artists produce such beautiful designs in colours, incomparable for their freshness and brilliancy. A second quality of the article, of darker tint, is used by the makers of paper umbrellas, parasols, and lanterns, to smear the fine stretchers of bamboo on which they are formed. When thoroughly dried, these articles of such extensive use acquire an impermeability of long duration. ('Scient. Amer.').

The seaweed *Arachnoidiscus japonicus*, which is used by the Japanese and Chinese to pack porcelain and other articles for exportation, is said to be made use of in France for the purpose of making artificial fruit jellies.

Consul Quin gives the following description of the method in which Japanese cut seaweed is prepared for the market. For making the finest cut seaweed, the best long seaweed is used, the newer the better on account of the colour. After the bundles are opened they are picked, and as much sand as possible is shaken out; the selected weed is then placed in large boilers, and is boiled for an hour or more, until the proper colour is obtained, which should be quite uniform and of a good clear green. After boiling, the seaweed is hung up on poles in the air to partially dry it, after which it is again carefully sorted, and all ragged pieces and those of a pale whitish colour are rejected; the selected weed is then handed over to a number of women, who open it out and roll it into flat coils of about 10 lb. each. As soon as these coils have remained long enough to flatten the seaweed they are uncoiled, and the pieces of weed are laid out one on the top of the other, on a board a little over 4 ft. long, to the depth of 8 to 10 in.; they are then cut into 4 lengths of 13 in. each, and these pieces are tied into bundles ready for the workmen to lay in the presses, which are about 6 ft. wide, 13 in. deep (the length of the pieces of seaweed), and 6 ft. high. At the bottom, a row of wooden slats, about 2½ in. broad, ½ in. thick and 13 in. long, are placed edgeways, and upon these the weed is laid carefully piece by piece in the frame, the sides of which are kept in position by a rope stretching across the top; a moveable plank at the back, which is raised as the workman proceeds, keeps the weed thoroughly even. When the frame is full—about 2 tons going into one press—a similar lot of slats to those at the bottom are placed on the top of the seaweed, and the whole is pressed as tightly as possible by means of a rough capstan, to get rid of all unnecessary moisture and to render the mass firm enough for cutting. The frame is then laid down flat; and one of the side planks being removed, the compressed weed is planed with an ordinary carpenter's plane, so as to cut it to the required thickness—about $\frac{1}{20}$ in.—along the edges and with the grain. The object of the slats is to enable the workman to plane to the edges, and they are removed one by one as he progresses with his work. Each man can plane on an average 170 lb. of seaweed per day. After planing, the cut seaweed is taken out of doors and shaken out to dry on mats; under favourable circumstances, one day is sufficient for this operation, but it frequently happens that as many as 3 days are required before it is dry enough to pack away. After the final drying, the weed is ready for the market, and is packed away in boxes containing about 66 lb. each. The rejected ends of the first class seaweed are used up, together with ordinary long seaweed of an inferior quality, to make cut seaweed of a lower class. While undergoing the various processes, the material loses 20 per cent. in weight, and that fact, joined to the price of the labour expended in its manufacture, brings the cost to more than double the average of long seaweed. ('Roy. Soc. Arts Jl.')

Thao is a very interesting substance, and one which is likely to come into considerable demand in the future. It is a gelatinous preparation made in Cochin China, as well as in other eastern countries, from seaweed. In the English market, it has frequently appeared, under the name of Chinese or Japanese isinglass, in three different forms. That which is prepared in Cochin China is in bundles of thread-like pieces, a foot or more long, about the thickness of whipcord. The specimens prepared in Japan occur in two forms, one in square sticks about 11 in. long, and 1 to 1½ in. in diameter, and full of cavities, each weighing only about 3 dr.; and the other in bundles of long shrivelled pipe-like pieces, about ⅛ to ¼ in. in diameter, and about 14 in. long. The bundles are fastened at the ends with the stems of some grass. When immersed in water, these pieces are seen to have the same square shape as the other varieties. One side of the pieces is always more full of diatoms and other foreign bodies, as if the pieces had been formed in a mould in which the sediments of the jelly had gone to the bottom. The cord-like variety made in Cochin China is in long loose bundles. It has much the polished appearance of the Chinese vermicelli made from rice, but that substance will not bend and is much more slender. Various trials have been made with it in France since 1874, especially by D. Gantillon and Co. at Lyons, and the Industrial Society at Rouen. The *thao* is prepared for use in the following way. After having been soaked in cold water for about 12 hours, it is boiled for ¼ hour, during which it absorbs about 100 times its weight of water. If allowed to cool, it becomes a jelly; but if passed through a sieve and stirred until cold, it remains fluid, and in this state is more easily employed than when hot. The yellowish matter which some specimens contain can be removed by boiling for some time, when it forms an insoluble scum.

which appears to consist of very thin fibres, and which remain attached to the sides of the vessel. A singular property, and one which perhaps might be turned to valuable account, is, that *thao* jelly does not decompose solution of permanganate of potash, even when left in contact with it for 24 hours. According to Heilmann, of Rouen, *thao* produces, in the proportion of 1 part to 100 of water, a dressing which is supple and strong, and which gives substance rather than stiffness to calico; while dextrine, like starch, makes the tissues drier and harder, and gives less facing to the thread. The addition of glycerine gives a dressing still more flexible and soft, and while rendering the tissues less stiff it communicates more body to them. The addition of talc gives still greater smoothness. Once dissolved, according to Gantillon, *thao* will mix while hot with any gum, starch, dextrine, or gelatine. The principal advantages of *thao* in dressing silk fabrics is, that while preserving their suppleness it gives them greater glossiness, and makes them soft to the touch. The mixture of *thao* with gum tragacanth is said to be the best method of using it. *Thao* should, however, be used alone for materials which it is not necessary should be stiffened. As *thao* is only soluble at a high temperature, a moist atmosphere, fog, or even rain, does not affect the material dressed with it. It combines well with sulphate of copper and the chlorides of aniline and potassium, and can be used in double dyeing. It also answers well for sizing paper, etc. The only obstacle to its extensive use is its high price. There is, however, no reason why a similar substance should not be made from our common native seaweeds, of which *Gelideum corneum* and *Gracilaria confervoides* approach most nearly in character the algæ from which *thao* is made. Gelose, of which *thao* consists, differs from the carrageenin obtained from *Chondrus crispus* in its power of combining with a very large quantity of water to form a jelly; it yields 10 times as much jelly as an equal weight of isinglass. For purposes of food, *thao* jelly is not quite so pleasant as animal jelly, as it does not melt in the mouth; it also contains no nitrogen. A great advantage which it possesses is, that it is but little prone to undergo change—so much so that the jelly is sometimes imported from Singapore, sweetened, flavoured and ready for use, and may in this state be kept for years without deterioration. The west coast of Australia also yields a seaweed possessing similar properties. *Porphyra vulgaris* (the "laver" of English coasts) is given as the source of the seaweed isinglass in square sticks. In Cochin China, this variety appears to be known under the name of *mat*. A number of other seaweeds are, however, collected, and are known to the Annamites under the general name of *rau-cau*, while in Chinese medicine they are called *hai-thao*. These algæ are gathered in considerable quantities in the islands of Cu-lao-Khaoi and Cu-lao-ré, those collected in the latter being considered of the better quality. ('Pharm. Jl.')

Test for goodness of Glue.—Assuming that that is the best glue which will take up most water, take 50 gr. of the specimen and dissolve it in 3 oz. water in a water-bath. When dissolved, set it by for 12 hours to gelatinise, and then take an ounce chip-box, place it on the surface of the gelatine, and put shot into the box until it sinks down to a mark on the outside. It will be found, that the stronger the glue the more shot it will take to sink the box down so that the mark shall be level with the surface of the gelatine. In a trial with very fine glue, 50 gr. of glue, dissolved and gelatinised with 3 oz. of water, supported to the mark on the box 6 oz. of shot at a temperature of 58° F. On trying the same experiment with best Russian isinglass, 9 oz. of shot were supported, the temperature being the same. This test is of course intended as a comparative one between two kinds of glue, or between any kind taken as a standard and another compared with it. The placing of the mark is arbitrary.

To Bleach Glue.—Soak in moderately strong acetic acid for two days, drain, place on a sieve, and wash well with cold water. Dry on a warm plate.

GLYCERINE.

Modes of Preparation.—The researches of Chevreul, which demonstrated the constitution of fats, showed that glycerine exists in nearly all neutral fats in a combined state, and small traces of it have lately been discovered uncombined in palm-oil. It is formed, as Pasteur has shown, in the process of fermentation. 100 parts cane-sugar forming 3·5 parts glycerine. For practical purposes, however, glycerine is always obtained from the bye-products of candle and soap factories. Cap worked out the first process for preparing it on a commercial scale from the waste liquor of saponification of tallow by lime in the first stage of stearic acid making. Early in 1854 Tilghman produced it by pumping an emulsion of 2 parts tallow and 1 part water through a coil of pipe heated to 612° F. (322° C.), after which the emulsion separated into 2 layers, the upper one of fatty acids, and the lower of glycerine and water. Several modifications of this were afterwards patented, but the only one worked on a large scale was that of G. F. Wilson and G. Payne, under which enormous quantities of glycerine have been made by Price's Candle Co. In this process, neutral fats are put into a still provided with a fine steam-worm, and a fractional condensing apparatus of large surface similar to that used in candle-making; they are then heated to between 550° and 600° F. (288° to 315° C.), and plenty of superheated steam is injected; mixed vapours of fatty acids, glycerine, and water are carried over to the condense, where the divisions nearest the still collect only fatty acids, while those farthest from it yield mixtures of fatty acids with glycerine and water in various stages of concentration. Glycerine so made can be concentrated in a vacuum-pan. Care must be taken that the temperature does not exceed 600° F. (315°C.), and that plenty of steam is present, else some of the glycerine is decomposed, and acrolein, a compound most irritating to the eyes, is formed—

$$\begin{array}{lcl} \text{Glycerine} & = \text{Water} & + \text{Acrolein} \\ C_3H_8O_3 & = 2H_2O & + C_3H_4O \end{array}$$

Raw glycerine is also prepared from the water employed to wash the fatty acids after acidification of the neutral fats. The acid liquid is neutralised by carbonate of lime or of baryta, either of which may be added until effervescence ceases; it is then concentrated to 28° B. in an open, shallow, cast-iron pan. Of late, however, glycerine has become sufficiently valuable to cause candle manufacturers to adopt that method of preparing fatty acids which gives them the greatest yield of glycerine from neutral fats. This process called the autoclave, is now very extensively used for glycerine-making, both on the continent of Europe and in England, and is thus conducted: About 1 ton of fat, usually mixed tallow and palm-oil, is heated with 2 per cent. lime and ⅓ the fat-volume of water, in an upright Papin's digester, under 8 atmos. pressure for 4 hours. The whole is then blown out into a tank, and the "sweet water" is run off. The lime-soap is decomposed in the usual way with sulphuric acid, and the resulting fatty acids are either pressed or acidified and distilled for stearic acid. It is then concentrated in a modification of the "Wetzel" evaporating-pan (originally introduced for sugar-boiling). This *évaporateur universel*, which is very economical and effective, consists essentially of pairs of saucers set edge to edge upon a hollow central revolving shaft, through which steam passes to the interior of the saucers (the waste steam from a high-pressure engine will do); the lower edges of the saucers dip in a jacketed trough of the liquid to be evaporated, and when they are revolved, layers of this are brought up and speedily concentrated on their surface. It may also be worked in a vacuum. Evaporation is continued to 26° B., when the glycerine is of a brownish colour and known as "raw" in which state it is sold for many purposes. At Price's Candle Co.'s works, the further purification is conducted as follows: The raw glycerine sp. gr. 1·245 to 1·250, is heated in a jacketed pan with that kind of animal charcoal known as ivory black, and is then distilled; this alternate treatment is repeated as often as may be necessary. The distillation is performed with superheated steam in a copper still provided with copper fractional condensers, the still being also heated externally; the operation is performed at as low a temperature as is consistent with distillation, usually about 440° F. (227° C.). The number of distillations depends upon the quality of the raw glycerine and the purity of the product demanded. Of the 6 runs, Nos. 1, 2, and 3 usually give pure glycerine, while the dilute condense products from Nos. 4, 5, and 6 are generally returned to the still, though occasionally concentrated in an *évaporateur universel*, or in a vacuum-pan. Some stills hold as much as 3 tons, but they are usually smaller, and in all cases the process is conducted very slowly. A form of still and condenser much used on the continent of Europe is outlined in Fig. 227. External heat and injected superheated steam are used to effect distillation. The still A has an unusually large head B, and the gooseneck C is provided with a catch-box D, in case the still-contents should, as sometimes happens, boil over; the fractional condensers E are upright cylinders with longitudinal partitions F running nearly their whole length; the condensed products run out through G into receptacles H. The whole apparatus is of iron, and usually made to distil ½ ton at a time; in some cases the process is conducted continuously, with a properly-arranged feed.

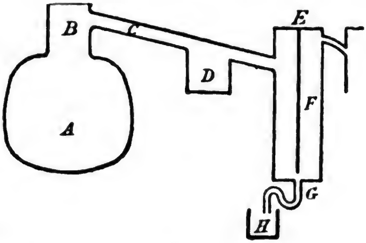

FIG. 227.

Enormous quantities of glycerine are run to waste in the spent lyes of the soapmaker. One of the earliest attempts to extract it was a patent by

H. Reynolds, for concentrating the spent lyes, and distilling off the glycerine by superheated steam between 380° and 400° F. (193½° to 204½° C.); the large quantity of sodium salts, especially sodium chloride, was found, however, to be an almost insuperable difficulty. A patent was taken out by C. Thomas, W. J. Fuller, and S. A. King, of Broad Plain Soap Works, Bristol, by which process the first successful production of crude glycerine from spent soap-lyes was introduced into commerce, and several tons per week are now manufactured. The specification states that they "evaporate the spent or partially spent lyes until the boiling-point of the liquid rapidly rises, when nearly all the salts that can be thrown down by simple evaporation are deposited in the pan. The resulting liquor is chiefly composed of raw or impure glycerine. This we draw off into a second pan, and boil it with excess of fatty acid, which, readily combining with some of the salts in solution, separates them from the liquor, and at the same time removes from it the fine crystals of salt formed during this operation. After this treatment, we skim off the saponified fatty matter, allow the liquid to cool, and filter it to remove the gelatinous, albuminous, and other impurities. The clear liquid may then be refined, distilled, or concentrated, as desired."

A study of the various patents that have been granted in connection with the recovery of glycerine is thus summarised by Kingzett:—

Constant Victor Clolus neutralises soap-lyes with hydrochloric acid, and evaporates the settled liquor till it registers 32° B. Heated air is then blown through to remove the rest of the water, the salts deposited during both stages being fished out and treated in a turbine. The final product may be finished by drying *in vacuo*. The crude glycerine thus obtained is said to contain but little salt, but the exact amount is not stated. It may be distilled in order to purify it. So far he fails to detect anything of an original character in this proceeding. Instead, however, of neutralising the soap-lyes with hydrochloric acid, the patentee may use carbonic anhydride, so that when evaporation has been carried to 25° B., after further exposure to carbonic anhydride, bicarbonate of sodium (being only slightly soluble in a glycerine solution of salt) is precipitated upon cooling. Another mode of freeing his crude glycerine from salt consists in treating it with excess of hydrochloric acid of 22° B., or in the form of gas. The solubility of the salt is said to be thus diminished, and in consequence more of it can be removed. The excess of hydrochloric acid is subsequently got rid of by a current of air, or by an excess of plumbic oxide.

Benno, Jaffé, and Darmstaedter employ sulphate instead of chloride of sodium for salting out the soap. They then neutralise the spent lyes with sulphuric acid, filter, evaporate, and thus get only sulphate of sodium separated. They say the sulphate is removed more easily than the chloride, and hence the value of this method seems to turn on whether the increased ease of removing the salts more than atones for the increased cost of material for salting out, because the only comparable difficulty in removing the chloride is one of cost.

George Payne neutralises the lyes with an acid, allows any precipitate to settle, and then adds a 10 per cent. (by weight) solution of tannin or tannic acid, until albuminous matter is no longer precipitated. The filtered liquor is concentrated by heated air or superheated steam, or direct by fire. He thus gets, he says, a crude solution of glycerine containing about 10 per cent. salts, which may be more easily refined than any other crude glycerine. In connection with this patent, Kingzett regards it as pertinent to ask whether the excess of tannin introduced is not as objectionable as the matter thereby removed.

C. Thomas and A. Domeier concentrate the lyes and add an excess of acid until there is present about 1 to 1½ per cent. free acid. This is to decompose any soap, eliminate resinous matters, and to so act on other matters that, when neutralised by alkali later on, they are precipitated. After this neutralisation and settlement, the lyes are further concentrated, and the crude glycerine is extracted with about 33 per cent. of coal-tar oil or petroleum, or bisulphide of carbon, or amylic alcohol, or ether, or other menstruum in which the glycerine is insoluble, in order to remove any soluble matters which may be disagreeable to the smell or taste. After extraction, the glycerine is subjected to hot air or steam in order to get rid of traces of the solvent employed, and may then be used for commercial purposes, or further purified by distillation. They also describe an apparatus designed for the concentration of thin lyes, in which the liquor slowly descends a tower fitted with alternately-inclined shelves, and in which it encounters a current of hot air, much in the same manner as Leather proposed to make bleaching-powder, viz. by causing lime to encounter an ascending current of chlorine gas in its descent down a tower fitted with a continuous spiral shelf.

J. Weineck avoids the use of both chloride and sulphate of sodium in soapmaking as follows: He exposes fats in a cylindrical wrought-iron vessel, fitted with a stirring gear, and provided with a jacket which is filled with hot water. At 113° F. (45° C.), the tallow (when that fat is used) melts, and then 20 per cent. of a 2 per cent. solution of soap at the same temperature is added to the fats, stirring meanwhile. When the mass is perfectly emulsified, caustic lye of the same temperature is added. When well mixed, the temperature is raised to about 194° F. (90° C.), and the stirrer is kept at work until saponification is completed. After some hours, the spent lye is let off, and registers 5° to 10° B. Operating thus, he claims to utilise some chemical heat evolved in the action of the lye upon the emulsified fats, and by saponifying the fats in this globular state he says he saves fuel, time, labour, cost on plant, and, above all, obtains lyes free from any large amount of salts. But even in this process, assuming it works otherwise satisfactorily, it would appear that the alkaline lye must be neutralised with an acid before concentration, otherwise the glycerine would suffer decomposition. Perhaps in such a case, however, carbonic anhydride could be profitably employed.

Reviewing these various specifications, the different processes described therein are designed to effect the following objects:—

1. To remove or destroy albuminous and resinous matters, together with any residual soap contained in spent soap-lyes.
2. To facilitate the removal of the salt, either by employing means to diminish the solubility of chloride of sodium, in cases where that substance is used, or to substitute for it another, which may be more readily and profitably removed.
3. To economise the cost of concentrating the purified lyes to that point at which the glycerine may be at once employed for certain purposes in its then crude condition, or still further purified by distillation.

Kingzett very much questions whether the alkali utilised by the carbonic anhydride process would pay for the cost of the gas necessary to be employed, except, perhaps, in conjunction with Weineck's process; and he equally doubts whether the cost and trouble of increasing the insolubility of chloride of sodium in glycerine liquors, by the employment of hydrochloric acid, would even be balanced by the effect produced. Speaking generally, therefore, and after giving a considerable amount of practical attention to this subject, the soapmaker who wishes to recover the glycerine from spent lyes cannot do better at present, it would appear to Kingzett, than proceed to evaporate the water from the neutralised liquor in the most economical manner available, with the dual object of getting rid, by deposition and crystallisation, of as much salts as possible, and of preparing the crude glycerine for distillation, and surely he can do all this without the use or infringement of any patented process—indeed, it is being done on a large scale. But there is another way of dealing with the production of glycerine already known and practised, and which will, Kingzett feels sure, be much more widely adopted in the course of time. At present the soapmaker saponifies neutral fats and oils with caustic lye, and then, at an expensive rate, seeks to recover the glycerine left in the lees; but, theoretically speaking, he would be better advised to decompose the fats and oils, in the first place, in the manner that is practised by the candlemaker, viz. by the agency of superheated steam, with or without the assistance of sulphuric acid or lime, using the fatty acids for saponification with alkali, and obtaining comparatively pure glycerine in this direct manner. The practical objection to this procedure is that the existing plant of soapmakers is not adapted to the process, and moreover, they cannot produce such good-coloured soaps from the fatty acids as result from the direct saponification of fats. But this is largely a sentimental objection, the soap being really equal in quality, and, so far as the objection is sound, Kingzett is confident that at the right time it will be overcome. ('Jl. Soc. Chem. Ind.')

It may be remarked that Clolus's process has been in successful operation for some time at his works at Billancourt, near Paris, while additional works have been erected at Marseilles, Runcorn, and Glasgow.

In an article in the 'Seifen-fabricant' Fleming pointed out that lyes contain between 0·92 and 7·8 per cent. of glycerine. Before being able to recover the latter, it is necessary to remove the sodium chloride, which is best done by osmosis. The lyes are first evaporated by steam until the liquor contains at least 20 per cent. of glycerine. It is then neutralised with sulphuric acid. The quantity of the acid required varies much, as the liquors contain from 1·9 to 19·9 per cent. of sodium carbonate. Where soda ash has been used instead of sodium chloride for the purpose of salting out, as much as 31 per cent. of alkali has been found in the lye after evaporation. It is advisable to use a slight excess of sulphuric acid, afterwards to let the liquors stand to crystallise, and then to neutralise them with lime; after settling, they are further evaporated. They should now contain no less than 40 per cent. of glycerine, but may contain as much as 66 per cent. The specific gravity is about 1·28; the ashes about 13 to 16 per cent. At this stage the cost of 1 lb. of glycerine is about 1¼*d*. The liquor is now ready for osmosis, by which process the ashes it contains are so far reduced that after further evaporation it can be distilled either by itself or with crude glycerine from stearine works. The loss on distilling is small, and the product pure enough for dynamite works. When evaporated to 1·26 specific gravity, and therefore free from water, it contains no sodium chloride. The lyes do not attack the parchment paper, as they contain no lime compounds, the paper having been found in good condition after 6 months' usage. The patentee calculates the cost of 1 lb. of 60 per cent. glycerine at 2¾*d*. The water of osmosis contains a considerable quantity of glycerine. In one experiment, 1400 lb. of the water gave 23 lb. liquor, containing 16 lb. glycerine, at a cost of about 2¾*d*. per lb. This product, contaminated with salt, and therefore not as pure as that obtained in stearine works, was still found as pure as a common Dutch glycerine of 63 per cent. which cost 1*s*. per lb. In the patentee's opinion, the proposal of using only fatty acids in soapmaking, and of decomposing the fats for that purpose in an autoclave, promises but little success.

In a subsequent patent, Fleming obviates the diffusion of the glycerine by replacing the ordinary parchment paper by a guttapercha membrane, which is proof against the passage of glycerine.

O'Farrell evaporates the soap lyes to the saturation point of sodium chloride, and uses it again to precipitate fresh soap. This is repeated till the lye is very rich in glycerine. The solution is next evaporated till all the salt crystallises out, and is then distilled *in vacuo*, with a steam jet at about 392° F. (200° C.). The distillate is heated a second time with low surface-heat only, to separate the water as steam.

Dr. Versman separates a large percentage of the salts in soap-lyes by simply boiling down the soap-lye and raking out the salts as they become insoluble ; he then allows the concentrated solution to cool, after which carbonic acid gas is passed through it until the whole of the carbonate and caustic soda is converted into bicarbonate of soda, which is much less soluble in glycerine than either the carbonate of soda or the caustic soda, and may readily be removed by filtration or other convenient means. The liquid from which the bicarbonate of soda has been removed is rich in glycerine, but it still retains sensible quantities of chloride of sodium and other salts, the presence of which may act injuriously in the subsequent application of the glycerine to certain purposes. These salts the patentee separates by submitting the liquid, either hot or cold, to the process of osmosis in an apparatus known as the "osmogene," such as is used in the separation of saline compounds from solutions of beet-root sugar ; by this process nearly all the salts are separated from the glycerine ; but as the latter becomes diluted with water, it is concentrated by evaporation, when it will be ready for the market as crude glycerine. Instead of commencing the treatment by boiling down the lye, carbonic acid gas may be passed through the original soap-lye, or, if preferred, the use of carbonic acid gas may be dispensed with ; but the patentee finds the most convenient and economical way is to first reduce the bulk of the liquid by boiling down, so as to separate large quantities of the salts, and then to treat the liquid with carbonic acid ; the subsequent treatment in the osmogene is essential in all cases. This osmogene is a modification of Graham's dialyser, and consists of 40 or more cells formed by sheets of parchment paper laid flat and connected at the edges all round, the space between each pair of sheets being fully ½ in. Each sheet is supported by a cross piece of wood and a network of string, and the whole affair is about 4 ft. long by 3 ft. high. Water is sent through alternate spaces, and the substance from which the salts are to be extracted through the others, the water by osmosis carrying off the salts and leaving a small quantity of itself in the glycerine or other substance.

F. H. T. Allen's process is as follows : First, if necessary, he neutralises the soap-lye with any ordinary mineral acid, and agitates ; after settling, he adds a solution of alum, or solid chloride of lime (bleaching-powder), or crude pyroligneous acid, and stirs thoroughly ; or evaporates to nearly salting point, before adding any of the substances named above. He allows the precipitate to fall, leaving a clear liquor, and after settling, draws off the clear upper liquor, and evaporates to concentration in pans (in which the heat is only applied at the sides). Finally, he distils this liquor in a glycerine retort, having a current of superheated steam within, and provided with an exit pipe at the bottom, which carries off the precipitated salt as it accumulates.

J. P. Battershall heats the liquors with steam, neutralises with sulphuric acid, and concentrates to $\frac{1}{10}$ their original bulk. A slight excess of acid is added, if necessary, to separate the resin and fat. Carbonate of lime is then added to again neutralise the liquor ; the latter is cooled, and the liquor separated from the crystallised salts in a centrifugal machine. The liquid is then distilled to purify the glycerine from the residual salts. Alcohols can be used instead of distillation, the precipitated salts (insoluble in alcohol), filtered or fished out, and the glycerine and alcohol separated by distillation. The crude glycerine can then be decolorised by filtering through bone-black.

Although evaporation and distillation are the usual methods of purifying glycerine, the action of cold upon more or less dilute glycerine is sometimes employed in conjunction with them. When an aqueous solution of glycerine partially freezes, the frozen mass contains more water than the remaining liquid ; hence some amount of concentration may be thus effected. The following table gives the freezing-points of such mixtures :—

Glycerine, per cent.	Sp. Gr.	Freezes.
10	1·024	− 1° C.
20	1·051	− 2°·5
30	1·075	− 6°
40	1·105	− 17°·5
50	1·127	− 31°·3
60	1·159	Below − 35° C.
70	1·179	
80	1·220	
90	1·232	
94	1·241	

Another authority gives :—

	sp. gr.	sp. gr.	sp. gr.	sp. gr.
Glycerine . .	10° B.	12° B.	14° B.	15° B.
Melting-point .	9° C.	13° C.	18° C.	21° C.

Some glycerine sent in tin cans from Germany to England froze into pea-sized octahedral crystals ; these while melting had a constant temperature of 45° F. (7·2° C.), but would not freeze again even when cooled to 0° F. (−18° C.). According to Werner, commercial glycerine will freeze more readily if chlorine gas be passed into it. In purifying glycerine by cold, the whole mass is cooled to nearly 32° F. (0° C.), and some crystals of solid glycerine are added ; almost the whole mass solidifies on agitation, and a centrifugal is used to separate the solid from the liquid parts. Treated in this way, glycerine at 28° B. yields crystals which, when melted, are 30·8° B.

Properties.—Pure glycerine is a viscid, colourless, and transparent liquid, with an intensely sweet taste, soluble in water in all proportions, in alcohol, chloroform, and carbon bisulphide, but not in ether ; its sp. gr. is 1·267 ; it solidifies at −32° F. (−40° C.) to an amorphous mass. When distilled, it decomposes, unless steam be present, hence its boiling-point cannot be accurately determined at atmospheric pressure. According to Bolas, at 12·5 mm. pressure it boils at 355°F. (179·5°C.), and at 50 mm. at 410°F. (210°C.); while Heminger gives 354° F. (179° C.) as its boiling-point under 20 mm.

It burns with a clear flame like oil, if there be free access of air and a high temperature for kindling it.

Adulterants.—Commercial glycerine is liable to contain various impurities, arising from its mode of preparation ; also certain adulterants, of which cane-sugar and glucose are the chief. Glucose may be detected by the brown colour formed when the suspected glycerine is boiled with caustic soda ; cane-sugar is shown by its deposition when the glycerine is agitated with chloroform, or, more certainly, by a polarising saccharimeter, since glycerine has no rotatory action on the plane of polarisation. Lead is detected by sulphuretted hydrogen ; lime, by the addition of alcohol and sulphuric acid, a white precipitate of calcium sulphate being formed ; butyric and formic acids, by the characteristic smell of their ethers, produced by boiling the suspected glycerine with alcohol and strong sulphuric acid; oxalic acid by the addition of calcium chloride and ammonia; sodium chloride by the addition of silver nitrate, which should give no precipitate with pure glycerine after 24 hours' standing. A rough and ready test for impurities generally is to agitate the glycerine with an equal bulk of chloroform, when they collect in the intermediate layer.

Under the title of "Adulteration of Glycerine" F. Jean contributes an article to the 'Journal de Pharmacie d'Alsace-Lorraine,' in which he considers not merely adulterations intentionally added, but impurities due to carelessness in its manufacture or purification. Among them are oxide of lead, lime, and butyric acid. French perfumers and manufacturers of cosmetics test their glycerine with nitrate of silver. If no turbidity or change of colour takes place in 24 hours it is considered good. The chloroform test for glycerine consists in mixing equal volumes of chloroform and glycerine, shaking thoroughly and then letting them stand. The upper stratum is pure glycerine, while the lower one is chloroform containing all the impurities. If there were no impurities in the glycerine, the chloroform remains unchanged, otherwise there will be a turbid layer just beneath the glycerine. On adding a few drops of dilute sulphuric acid to a mixture of equal parts of glycerine and distilled water, and then a little alcohol, the presence of lime or lead will be shown by a white precipitate. The latter is reorganised by sulphydric acid, which turns the precipitate black. Butyric acid is detected by mixing the glycerine with absolute alcohol and sulphuric acid of 66° B. On gently heating the mixture the butyric ether is easily recognised by its agreeable odour. Formic and oxalic acids are also found in glycerine impurities which are of special importance to pharmacists. They are detected as follows: Equal volumes of glycerine and sulphuric acid, sp. gr. 1·83, are mixed together. Pure glycerine does not give off any carbonic oxide gas, but if either of the acids mentioned is present, an evolution of that gas will be observed. To decide whether both acids are present, and if not which one, some alcohol of 40° B. and one drop of sulphuric acid are added, and then gently heated. Formic acid (used in making essence of peaches) will be recognised at once by its characteristic odour, and proves the presence of formic acid. To another sample of the glycerine add a little solution of chloride of calcium (free from carbonate), when it will give a precipitate of oxalate of lime, if oxalic acid is present. Sugar, glucose, dextrine, and gum are often used as intentional adulterations of glycerine, and are tested for as follows: The glycerine is mixed with 150 or 200 drops distilled water, and ½ gr. molybdate of ammonia is added, and one drop of pure nitric acid. It is boiled about 30 seconds. If sugar or dextrine is present, the mixture will be blue. Glycerine adulterated with loaf sugar or syrup acquires a brownish black colour when boiled with sulphuric acid. Glucose is detected by boiling it with caustic soda, which turns it brown. If detected qualitatively, the quantity may be estimated by the following method: 5 grm. glycerine are weighed out and mixed with 5 c.c. distilled water. It is boiled in a little flask, with Barreswil's alkaline solution of tartrate of copper. The suboxide of copper is precipitated, and the precipitate is dissolved again in hydrochloric acid. An excess of ammonia is added, and it is poured into a vessel containing an excess of nitrate of silver. A precipitate of metallic silver is formed and filtered out. It is washed with warm water and ammonia, calcined at a red heat, and weighed: 109·6 parts metallic silver represent 100 of glucose. If cane sugar or dextrine is found, it is boiled for ½ hour with acidified water to convert these substances into glucose. If none of these impurities is present, the amount of water is found by Vogel's well-known method.

Dr. Odling mentions the curious fact that hydrocyanic (prussic) acid is an excellent test for the purity of glycerine, the slightest admixture of any foreign substance causing the glycerine to turn yellow in a short time, if a little hydrocyanic acid be stirred into the liquid.

Use as Solvent.—According to Klever, 100 parts glycerine will dissolve :—

	Parts.
Acid arsenious	20·00
,, arsenic	20·00
,, benzoic	10 to 20·00
,, boracic	10·00
,, oxalic	15·00
,, tannic	50·00
Alum	40·00
Ammonia carbonate	20·00
,, muriate	20·00
Antimony tartrate	5·50
Atropine	3·00
,, sulphate	33·00
Barium chloride	10·00
Borax	60·00
Brucine	2·25
Cinchona	0·50
,, sulphate	6·70
Copper acetate	10·00
,, sulphate	30·00
Iron lactate	16·00
,, sulphate	25·00
Iodine	1·90
Lead acetate	20·00
Mercury bichloride	7·50
,, bicyanide	27·00
,, arseniate	50·00
Potash chlorate	3·50
,, and iron tartrate	8·00
Potassium bromide	25·00
,, cyanide	32·00
,, iodide	40·00
Morphine	0·45
,, acetate	20·00
,, muriate	20·00
Soda arseniate	50·00
,, bicarbonate	8·00
,, carbonate	98·00
Phosphorus	0·20
Sulphur	0·10
Strychnine	4·00
,, nitrate	0·25
,, sulphate	22·40
Veratrine	1·00
Zinc chloride	50·00
,, iodide	40·00
,, sulphate	35·00

Glycerine is particularly valuable as a solvent for gum-arabic, as also in paste. Glue, by continued digestion, is soluble in glycerine, gelatinising on cooling. Glycerine dissolves aniline violet, alizarine, and alcoholic madder extract. A solution of aniline colour in glycerine is often used for stamping with rubber hand stamps. Glycerine is employed to extract the perfume from flowers and the aromatic principle of red peppers. Sulphate of quinine dissolves in 10 parts glycerine when hot, but when cold separates in clots, which, when triturated with the supernatant liquid, gives it the consistence of a cerate, very useful for frictions and embrocations. Warm glycerine (50 parts) will hold in solution when cold 1 of salicylic acid ; 300 parts water may be added without causing precipitation.

Use in Textile Manufacture. Glycerine is daily becoming of greater importance to the textile manufacturer. As a lubricant of machinery it is invaluable and in many instances preferable to oil or greases, especially where such machinery is exposed to the action of the air or great alterations of temperature ; it neither thickens, freezes, nor gets rancid, thus keeping the rubbing parts constantly lubricated, which cannot be done by substances which desiccate and retain the dust flying about in the air, thus clogging the bearings. For lubricating purposes, the pure glycerine may be mixed with half its quantity of olive-oil. Glycerine does not attack metals like many oils which have been treated with acids.

Glycerine is not of inferior importance in weaving ; by its use the size will never tend to smell badly, and a hand-loom weaver may work at all times, either with an open window or with a large fire in his room; his yarn will always be in a good condition, and not become brittle, nor will cloth sized with a compound containing glycerine ever mildew or rot; and the following mixture is therefore recommended for this size, viz. 10 lb. farina, 24 lb. glycerine of 28° B., 2 lb. sulphate of alumina and 6 qt. water.

Glycerine is not only a good solvent for aniline colours, but it tends likewise to preserve for a long time the compositions of albumen, of casein, and solutions of gum used in finishing; it keeps them in a liquid state, and prevents them from putrefying through its antiseptic qualities.

It is also of great use for printing woollen or worsted goods, because the colours printed with it are thus, before the steaming, kept in a humid state, while in cotton printing it accelerates and favours the oxidisation of the mordants before the dyeing. In general, for finishing colours and mordants, 8 oz. suffice for 1 gal. For dyeing, printing, and finishing, it is not necessary that the glycerine be perfectly white, for when of a pale yellow it will give the same results, while its price will be much lower. Only for very delicate colours, such as ultramarine and others, it is advisable to take purified glycerine. Glycerine of 26° to 28° B. suffices, when exempt from acid or alkali—i.e. when it turns litmus paper neither red nor blue; glycerine of 30° is seldom used. It must not contain any lime, if it is to be used for colours. To test it for this, a little of the suspected glycerine should be poured into a test-tube, then mixed with half its quantity of water, and a few drops of a solution of oxalic acid is added. If the solution contains lime, it is clearly shown by the white precipitate which will deposit after a little rest.

Glycerine is sometimes adulterated with grape sugar, common syrup, or similar substances, especially when it has not been purified, and is still of a brownish colour; it loses in such a case a good deal of its aroma, but retains its moderate degree of fluidity, and the buyer is easily deceived.

In Dresden, glycerine is generally used in place of water in gas-meters; after it has been so used for some years it becomes foul and requires purification. The fluid is first heated for 12 hours to 122° to 146° F. (50° to 60° C.), and next to 266° to 302° F. (130° to 150° C.), in order to eliminate water, ammoniacal compounds, and other volatile impurities; the glycerine is next filtered over granulated animal charcoal. Some 300 to 400 cwt. of glycerine are annually purified in this manner at Dresden. It is said that the cloudiness produced on glass by water in a vaporous state (dew, breath, steam), may be prevented by wiping the surface with a rag moistened with glycerine. Glycerine coloured with aniline has been used in barometer tubes at Kew.

Glycerine Jelly.—(*a*) 12 oz. pure glycerine; 8 oz. white soap; 6 lb. bleached almond oil (in cold weather 8 lb. will be necessary); 2 dr. oil of thyme; 4 dr. oil of bergamot; 1 dr. oil of roses. Work the soap and glycerine together in a mortar, then gradually add the oils and work until the mass is well incorporated. This makes a soluble, transparent jelly for the toilet table.

(*b*) 6 fl. oz. of glycerine; 8 oz. Nelson's refined gelatine; 12 fl. dr. of solution of camphor in 90 per cent. alcohol; 16 drops oil of cloves; egg albumen. Let the gelatine soak in soft water for a night, then pour off whatever water remains. Put in softened gelatine in a double saucepan or into a pan which can stand in a vessel of boiling water (like a glue pot), and when the gelatine is quite liquid take it from the heat and let it cool to about 130°, or as cool as it can be without beginning to set. Now clarify it as follows: Add to it a good dessert spoonful of well-beaten white of egg, raise quickly to the boil, and boil for about 6 to 8 minutes. Take from the fire and stand in a warm place (to keep fluid) for a quarter of an hour. Now filter through flannel and the fluid should come through clear and bright. If not, then add more white of egg and boil up, let stand and filter again, as the filtered fluid should be quite bright. Let the mass cool until nearly about to set, then mix the oil of cloves in the camphorated alcohol, add this to the glycerine then add to the gelatine, and well mix. The mixture should be poured into bottles or jars before it sets.

* * *

GRINDING METALS.

IN presenting the following results of experience with surface grinding, I do not claim to point out the way to obtain absolute accuracy, but am confident that the hints here given will be of use to many in the effort to reduce the error limit. Best results are to be obtained only by the exercise of good judgment on the part of the operator, as a "sense" is one of the qualifications for the work.

I believe that much of the trouble experienced with grinding machines is due to the use of unsuitable abrasive wheels, and to a desire to force the wheel beyond its limit. It is also well to bear in mind that the size of the wheel bears an important relation to the successful removal of stock, and that heating is not necessarily harmful to the work if it is distributed evenly.

In doing precision surface grinding, every operator has doubtless run up against the following difficulties. In grinding wrought metal (especially machinery steel), difficulty is often experienced by the work showing a convex surface even after a very light cut has been taken. Sometimes when using the same wheel on the same work, the latter will show a concave surface. A chattery surface is a very common trouble experienced. In starting a light finish cut, it sometimes happens that a cut 0·001 in. deep will run out after a few strokes.

Taking up, first, the case of the convex surface, the operator would be apt to jump at the conclusion that the trouble is due to absence of water on the work, or that a strain had been relieved in the work by the cut. If the emery wheel be carefully examined, it will be found probably that it is more or less filled up with particles of the metal, and that these particles have in a measure transformed the wheel into a friction disc, the particles of metal rubbing down the surface of the work, forming a crust with an effect like peening to stretch the surface and cause it to become convex.

Now, in the second case, where the reverse happens, there is a seeming paradox. The explanation is that the wheel has been forced to cut beyond its limit, and that a good deal of heat has been generated, causing sudden expansion of the work immediately under the wheel where it is labouring the hardest. This, of course, causes the wheel to cut deeper at this point. As the wheel has gained added momentum at the starting end of the work, it enters on it at each end without much heat. When it is well into the midst of its cut, there is a culmination of heat, the work undergoes a temporary expansion, and the wheel cuts deeper.

The remedy in the first case is to use a softer wheel, taking light cuts, with coarse feed. In the second case, do not try to force the grinding wheel beyond its limit, or if you must use the grinder as a stocking-out machine, you must employ the freest cutting wheel obtainable.

Chattery work is due to several causes, any one of which will cause the trouble. First, a poor cutting wheel, second, an overworked wheel, and third, a machine lacking in rigidity. Also slack in the spindle will tend to encourage vibration. An entirely smooth surface is difficult to obtain with grinding machines, or, indeed, with any machine ; but a close approximation can be obtained by observing the following rules :—

Take up all slack possible in the spindle, true the wheel frequently, and run light cuts. The wheel must be given time to remove the metal, and the smaller the wheel the more time required.

Improved results are generally obtained by reducing the width of the wheel face. I usually bevel each side about 30°, leaving about ¼ in. more or less for the cutting face. The more pressure required to hold the wheel to its work, the more trouble with chatters : hence use wheels that will cut freely. Never let the wheel wear much tapering on the face. To prevent this, feed the platen or wheel backward as well as forward. The result of this will be that the face of the wheel will assume gradually a contour. This is better than to have it wear tapering or rounding on one side only and wedge on to the cut.

A special truing diamond should be added to the equipment of a surface-grinder, and should be arranged to be held on the platen directly under the wheel, and be fed under so that the wheel face may be made parallel to the work face. It is a good plan to true the wheel just before taking the finish cut on very fine work.

We will now suppose that the operator has mastered all the above details, has his wheel trued off, and wishes to grind off a finish cut of a fraction of a thousandth of an inch in depth. He sets the machine in motion, and everything starts off well for half a dozen strokes, when the cut suddenly runs out. I wonder if it ever occurred to this operator that oil must necessarily occupy some space, and that a spindle must necessarily have oil between it and its box. Also, if a spindle be stopped, that this thin film of oil must gush out somewhere, and the spindle settle down somewhat on account of its weight. This is the explanation of the mystery. The moment the spindle is stopped it commences to settle, and in its lowest position the wheel should not be adjusted to the work. When the spindle starts up, it gradually rises on the film of oil again. The remedy for the above trouble is simply to let the machine run for a minute before adjusting for the finish cut.

The result of the foregoing is embodied in the following "hints" for surface-grinder operators :—

First, make sure that the machine is lubricated, and that it runs freely in every part, especially in the emery-wheel adjustment.

Do not expect to adjust the wheel to fractions of thousandths of an inch without rapping on the index handle. Select an emery-wheel of as large a diameter as possible, and one that is coarse and free-cutting. On tough, tenacious metals like wrought iron, machinery steel, or brass, the best results in respect to finish are obtained by the use of fine soft wheels taking very light cuts with coarse feed. The wheel must wear away somewhat to insure good results.

A small wheel must not be expected to do the work of a large wheel in the same time ; finer feeds and slower platen speeds should be employed for small wheels. A grain of emery has the capacity for performing a certain definite amount of cutting before disintegration, hence two grains of emery in a wheel will perform double the work of one, and the latter will change its diameter twice as fast and produce work less accurate.

Speeding up an emery-wheel helps to keep it from wearing away; but the amount of the advantage is limited by practical considerations. A glazed or a filled wheel can sometimes be remedied by slowing it down, and thus forcing it to wear away. Avoid generation of heat as far as possible, although heat does not necessarily cause work to spring. All grinding wheels heat more or less, and little trouble will be caused by it if the heat is distributed evenly throughout the work. It is intense heat at one point that causes trouble.

Where much heat is likely to be generated, employ coarse feeds and very light cuts, and thus distribute the heat quickly. A cut 0·001 in. deep is a large cut for a finish cut. A cut 0·0001 in. deep is appreciable and looks larger, judging by the sparks. On precision work, always let the machine run idle for a minute before adjusting the wheel for the cut. The down feed must work easily to obtain best results. Keep all wear of spindle taken up.

Do not oil the grinding spindle in the midst of a cut. It will make a jog in the work. Coarse wheels of proper texture cut smoothly. The keynote of satisfactory grinding is "Free-cutting Wheels." Remember that the grinder is primarily a finishing machine—not a stocking-out machine. Water is useful on a grinding machine only for its cooling qualities. It does not prevent the work from springing. ('American Machinist.')

* * *

GUN "PROOF" MARKS.

As there are great numbers of second-hand and cheap new guns on the market, it is thought desirable, largely in the interest of colonial readers, to give some of the chief proof-marks that fire-arms may bear. This is done largely to guard the buyer against the thousands of cheap and poor quality arms of Belgian make that are exported, these costing, wholesale: guns, 16*s.* to 17*s.* each; revolvers from 2*s.* 6*d.* each.

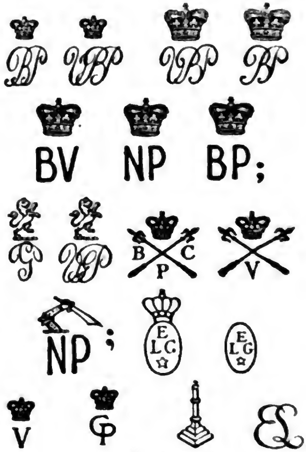

FIG. 228.

They sell at whatever the buyer can be persuaded to consider them worth, usually several times their true value. It is the best plan to see that a gun have an English proof mark. Such a mark may be forged, but in most cases it is reliable. Of the marks here shown (Fig. 228) the first four are old Birmingham (English) marks; the next five are new Birmingham marks; the following five are London marks; and the last four are Belgian. ('Exchange, Bazaar and Mart.')

GUTTA-PERCHA.

(*See also* INDIA-RUBBER.)

GUTTA-PERCHA is the solidified juice or sap of a forest tree, the *Isonandra gutta*, but the demand for this substance has been so great, the search for the tree so keen, and the destruction of the latter so great, that interested people have sought for, and found, other trees and plants that yield substances similar to gutta, and probably largely used in place of, or mixed with, the real article.

The uses for gutta-percha, both in the arts and sciences, are many and varied, but probably the chief purpose it is applied to is that of an insulator in electrical work and appliances. It has done splendid work in insulating some of our most important deep-sea cables. A property that gutta-percha possesses, rendering it particularly serviceable for so many purposes, is that of becoming soft and plastic when heated by dipping in very hot water. It is then easily and perfectly moulded to any form, will take the finest impression, preserving the sharpest of angles or edges, and set hard to the acquired form when it cools. It can be moulded or pressed into tubes and hollow forms and being innoxious and insoluble in water, it is made up into many forms of surgical appliances. A Dr. Oxley has published the fact that its being plastic when heated and hard when cold, makes it particularly suited for the management of fractures. It is slightly flexible when cold, so that although said to be hard, it is not so to the extent of being too brittle, hence its suitability for electric cable work. After being freed from impurities gutta-percha has a brownish-red colour, and a density slightly less than that of water. It is more or less soluble, at varying degrees of heat, in anhydrous alcohol and ether, in olive-oil, in benzene, bisulphide of carbon, chloroform, and oil of turpentine; but it resists the action of water, alkaline solutions, hydrochloric acid, and even hydrofluoric acid. Investigations made on the commercial gutta-percha as purified by solution in bisulphide of carbon, show that it is not a simple substance, but consists of a mixture of three principles. M. Payen found that from 75 to 82 per cent. of the mass was insoluble in alcohol, and this portion he has called *pure gutta*. The other two substances are called *alban* and *fluavil*. The former is soluble only in boiling alcohol, and forms about 19 per cent. of the gutta-percha, while the latter, which will dissolve in cold alcohol, constitutes about 6 per cent. These latter substances are believed to be gutta in different states of oxidation. Thus the gutta itself is a hydrocarbon having the same atomic composition as oil of turpentine, viz. $C_{10}H_{16}$, while alban is expressed by $C_{10}H_{16}O$, and fluavil by $(C_{10}H_{16})_2O$. It is remarkable that india-rubber and gutta-percha should have so many properties in common and yet be so different in others. Both are obtained from the sap of plants, both are hydrocarbons, both have the same atomic constitution, gutta-percha consisting of 87·8 parts of carbon and 12·2 of hydrogen, and caoutchouc of 87·2 of carbon and 12·8 of hydrogen, analyses which are sufficiently close to be considered as identical in result, and both, when distilled in the dry way, give rise to other and polymeric hydrocarbons. Thus from both are obtained *isoprene*, *caoutchin*, and *heveene*. Another analogous point is the porosity of each in thin sheets. When a drop of a solution of gutta-percha in bisulphide of carbon is placed on a glass and allowed to evaporate, a thin film is deposited, which has the appearance of a sieve when examined by the microscope. Pores are also seen in caoutchouc when treated in the same way. When the film of gutta-percha is drawn, a fibrous structure replaces the porosity; the film can be thus stretched to twice its original length. It will sustain a greater force without breaking. If it has taken 4 oz. to stretch it, it will bear a weight of 8 oz. without breaking. This porosity is one great drawback to its use for holding hydrofluoric and other strong acids in a diluted form, as it allows them to pass through to the outside of the vessel. With all this sameness, there is sufficient diversity between the two substances in their physical properties, and in their behaviour towards certain chemical reagents, to show that while there are the same ultimate atoms in each, these atoms are combined in different ways.

At the ordinary temperature of the climate in England gutta-percha, in thick pieces of about half an inch, is tough and but slightly flexible. At 115° F. it becomes pasty and soft, but still able to bear a considerable weight. Between 103° and 140° F. it is very plastic, and can be moulded into forms, spread out in sheets, or drawn into tubes. Pure gutta, on the other hand, is perfectly white, becomes transparent at 212°F. and turbid when cooled again. It fuses at 302°F. Exposed to ozonised oxygen, it rapidly becomes oxidised, and forms two compounds with strong hydrochloric acid.

In the collection and preparation of gutta-percha changes have been observed similar to those traced by the chemist in the laboratory. The gutta-percha of Surinam is obtained from the juice by two methods—by spontaneous evaporation, and by mixing the milk-like sap with absolute alcohol. When the gutta is separated in the latter way it is a snow-white opaque substance, which becomes yellow by exposure to sun and air. Besides this, there is another compound which becomes brown by oxidation. If this brown body once penetrates the gutta-percha it can only be removed with great difficulty, and hence it is that the ordinary commercial article is of a dark tint. Professor Bleekrode believes that the colour is due to the presence of gallic acid; and he notices that when gutta-percha is heated in contact with iron, as it is sometimes where iron machinery is employed, the brown is converted into black. India-rubber also probably owes its dark colour to the presence of the same body.

In a paper read before the British Association attention was called to certain changes which occurred in the fruits of certain trees yielding a gutta-like material, that, both in gutta and rubber, starch was a prominent ingredient. Following up this idea several compounds were made by mixing starch with tannin and oily substances. These compounds are analogous to gutta-percha, and can be mixed with it, and by mixing with gutta or rubber the hardness could be regulated at will. If desired, a substance like ebonite could be produced, having the same horny character.

One of the causes of change in gutta-percha is oxidation. When either gutta or gutta-percha is exposed to the air at a temperature of about 80°F. in thin sheets or threads, it gradually loses its tenacity, flexibility and elasticity. In summer time it has been frequently noticed that small objects made of gutta-percha become remarkably brittle. When large quantities of it are closely packed, a similar alteration takes place. An instance of this was afforded by 700 miles of gutta-percha covered wire which had been sent out to India. When it arrived there, it showed traces of having been raised to a temperature sufficiently high to melt the covering in places and expose the wire beneath. It was found that 500 miles of the wire had become so brittle by oxidation as to be useless for electrical purposes, and had entirely lost its property of insulation. That the change was due to oxidation was shown by an examination of the wire by Dr. Hofmann. The unaltered product contains, as already noticed, 87·8 parts of carbon, and 12·2 of hydrogen. The altered product was a brown, brittle mass, from which a brittle substance was extracted by cold alcohol, containing 62·8 per cent. carbon, 9·3 hydrogen, and 27·9 oxygen. From the remainder boiling alcohol extracted another brittle compound containing 67·7 per cent. carbon, 10·1 hydrogen, and 22·2 oxygen. The still insoluble remnant was unoxidised gutta-percha. There are many other instances on record. In one case a pipe connected with a pair of bellows, and suspended in air, became as fragile as glass in eight months. It was taken down, remelted, and rewrought; and in this way its toughness and soundness were restored to it. If, however, it be overheated, it retains its brittleness. Oxidation, however, is not the only cause of decay. Professor Bleekrode found that articles which had been varnished over became brittle more quickly than those which had not been so protected. In this case it is supposed the decomposition arose from the presence of impurities and carelessness in drying. When such gutta-percha is shipped to Europe the interior of the lumps are found to be decomposed by some fermentative process. It is believed that the stability of gutta-percha greatly depends upon the age and state of growth of the tree, the season when the sap is gathered, and, perhaps, other circumstances. Another and remarkable cause has shown itself in the case of the underground telegraph wires. It appears that the wires near Berkhampstead having failed, Mr. Highton, of the British Electric Telegraph Company, inquired into the cause of failure, and noticed that where the wires and wooden boxes enclosing them had passed near oak trees, they seemed to be peculiarly liable to destruction, and it was at such spots that the wires had become useless more than once before. On examining a few of these spots the boxing, although only a few months old, was in a decayed condition, although a few yards from the trees boxing which had been down for three years was yet perfect. So again with the wire, it was rotten in one place and quite sound seven yards off. The cause then was evidently local. In and around the places where the damaged parts occurred, a fungoid growth of a white colour prevailed, and wherever this came in contact with the gutta-percha, the latter was destroyed. A yellowish-green fungus, believed to be connected with the white fungoid growth, flourished under oaks, but not under the other kinds of trees. Wherever these plants were seen the wires were bad, and where they were absent the wires were good. To further establish the truth of his conclusions, Mr. Highton grew *Agaricus campestris* in contact with sound gutta-percha. After a time he found that the latter had lost all its insulating power, and that in four months the fungus had completely destroyed the gutta-percha.

In some cases, however, the covering of the wires was acted on by other means. A wire was carried through Winslow partly in wooden boxes, and partly—that is, for 46 yards—in iron tubes. The whole of the wire in the piping, excepting an inch at either end, had its gutta-percha covering destroyed, while in the wooden boxes all was sound. A similar circumstance occurred in the wires in iron pipes at Knowle, near Manchester.

For all practical purposes, it matters little whether india-rubber or gutta-percha be used for wires and cables, but the latter substance is the better insulator. It should be premised, that the insulating power greatly depends upon the skill and care with which the wire has been covered. Hence, it has happened that as improvements succeeded each other, now india-rubber, and now gutta-percha, was considered the better insulator. The great value of gutta-percha is testified by the fact that thousands of miles of submarine telegraph wires covered with gutta-percha are now submerged, and that, of the hundreds of miles which have been taken up and examined from shallow water and from deep water, the covering has always been found sound.

Experiments on the strength of gutta-percha tubes have been made as follows. A length of 1000 ft., having a bore of 1 in., and a full diameter of 1 3/16 in. sustained a hydraulic pressure of 100 lb. on the square inch with ease. A piece cut off from it bore 266 lb., and burst at 272 lb. pressure. Another piece similar to the last, but somewhat thicker, was ruptured at 320 lb. on the square inch. A pipe in common use in Boston, and in practice subjected to a pressure of 60 lb., stood 320 and burst at 360 lb. Its internal and external diameters were respectively ⅞ and 1⅛ in. Two pipes of the same dimensions—viz. ½ in. bore and ⅝ in. in external diameter—but made by different manufacturers, gave different results. One sustained a pressure of 234 lb., but yielded to one of 240; while the other stood one of 360 lb. for a short time, and then gave way. In another experiment, a stout pipe of ¼ in. bore and ⅜ in. thickness, such as is used in shops for effervescing soda-water, and frequently subjected to a 200 lb. pressure, resisted 720, but not 760 lb. These experiments were made at the ordinary temperature of the water of one of the Boston reservoirs. According to Feistmandel, gutta-percha an inch thick will bear a pressure of 3744 lb. on the square inch.

The elasticity of gutta-percha has also been the subject of experiments by Adriani. For this purpose a piece of a new machine belt, 2·362 English inches wide, and about 0·069 of an inch thick, was fixed to a support by one end, and from the other were suspended weights. By looking through a telescope attached to an accurate cathetometer at some ink marks on the belt, a difference of one-hundredth part of a millimetre, or 0·00039 of an English inch, in the length could be detected. The original length of the belt was 0·66628 metre. A weight of 3 kilogrammes suspended to the end, and allowed to remain for one hour, increased it to 0·66987. With every subsequent hour a half kilogramme was taken off, and the following measurements indicate the stretching effect of the different weights:—

2½	kilogrammes	0·66944	mètre.
2	,,	0·66904	,,
1½	,,	0·66850	,,
1	,,	0·66795	,,
½	,,	0·66758	,,
0	,,	0·66679	,,

For 3 kilogrammes, then, the elastic stretch was 3·08 mm.; while the permanent stretch for the same weight was 0·5 mm. The temperature of the room during the experiments was constant at 62° F. The strength of this same piece of belt was then tried. It broke with a strain of 223½ lb.

The method of preparing gutta-percha is very simple. The following is an outline of the process adopted. The lumps are torn to pieces by a wheel, provided with strong teeth, so arranged in alternate rows that, when looked at sideways, the spaces between the teeth in the one row are filled up by the teeth in the next. The same cylinder contains a number of these series of teeth. The rasping action is aided by a stream of running water. The pulp thus obtained is washed thoroughly in three successive troughs of water. When washed it is spread on a large slab, water is dashed over it, and it is then passed several times between two rolling-mills, heated within by means of steam jets, until it is changed into a soft paste. When sufficiently blended and kneaded, the paste is cut through in the direction of the axis of the cylinder, and turned off as a thin sheet, which is immediately seized by two men, who, by skilful management, stretch it so as to increase its dimensions twice or thrice; by this means any impurities, such as bits of wood, etc., are readily detected and picked out. These sheets are so thin that they dry very quickly in the air; indeed, they are dried at the same time that the sheets are being incorporated together on a steam heated plate. When taken off, the substance is carried to a washing apparatus, consisting of two cylinders grooved in the direction of their length, and made to turn in opposite directions, so as to produce a strong rubbing action. A second heater, like the former one, is provided with a jacket which is heated by steam from one pipe. These various operations occupy about an hour. The gutta-percha is finally rolled into sheets of different sizes and thicknesses ready for sale, or else made into tubes by a machine similar to that used in manufacturing tubular macaroni, but modified for the special purpose, it being necessary to keep the substance warm and plastic.

The method of vulcanising gutta-percha is similar to that adopted with india-rubber, but, of course, the effect is less marked. By adding 2 per cent. of chloride of sulphur the resulting material can be extended; when heated to 100° to 120° F., and if kept extended until cool, it will remain in that state. On re-heating however, it will contract to its original size. If more chloride of sulphur is used, say 10 per cent., the material is not affected by the heat of boiling water, while 15 per cent. produces a horny substance.

Chatterton's Compound.—This compound is employed for uniting the different coatings of gutta-percha cores, and for cementing gutta-percha to wood, etc. It is sold in rolls about 1 in. thick, and 7–8 in. long. It should soften readily at 38° C. (100° F.), and become firm again when cooled for a few minutes. Its freshly cut surface should be smooth and compact; it should not break, but bend easily with slight elasticity; its sp. gr. is about 1·020, it should not become hard or brittle on exposure to the air. The following process is adopted for its manufacture—⅓ by weight Stockholm tar, and about the same weight of rosin, are put into a jacketed vessel, heated by steam, strained when melted, and intimately mixed with ⅔ by weight of cleansed gutta-percha in shreds or thin pieces. The whole is worked together by horizontal stirrers, fixed on a vertical shaft.

Artificial Gutta-Percha. — The German Telegraph Department has some cables of artificial gutta-percha in use which have so far given every satisfaction. The material is the invention of Adolf Gentzsch, of Vienna, and is described as a mixture of rubber and a palm wax of the same melting-point as the rubber. Electrically the product is considered equal to the natural gutta-percha, and it softens only above 60° C. (140° F.), the mixture remaining homogeneous at these temperatures. The manufacture of this artificial gutta-percha, was taken up by Messrs. Felton and Guilleaume, of Mülheim, and after experimenting, the Telegraph Department ordered a cable, nearly six miles in length, of the Mülheim firm for connecting the Island of Föhr with Schleswig. The cable consists of four strands, each of seven copper wires; with its covering of artificial gutta-percha, the diameter of each strand is 6 mm. (about ¼ in.), and the whole cable, with its jute and galvanised iron-wire sheathing, has a diameter of 36 mm. (1½ in.). The weight is 3½ tons per kilomètre (about 5½ tons per mile). An insulation resistance of 500 megohms and a capacity of 0·15 microhm were guaranteed. The tests were made at temperatures between + 30° and − 5° C. (86° and 23° F.), as the cables would be exposed to considerable temperature changes in the shallow water off the Frisian coast; an insulation resistance of 650 megohms was found, and the contract conditions were more than satisfied. The Gentzsch gutta-percha cables are 35 per cent. cheaper than gutta-percha cables. Although the artificial gutta-percha softens only at a higher temperature than the natural product, it is somewhat more sticky. Junctions and repairs are effected with the aid of Chatterton's compound and of natural gutta-percha. When the Föhr cable had sucessfully been laid, more cables were laid over to the Island of Norderney, in the mouths of the Ems and the Vistula, and at other spots in the North Sea and in the Baltic. The total length of these cables is 15 miles, and as they are in exposed positions, a few years' experience should allow us to get a good idea of their durability. ('Engineering.')

* * *

HOT-WATER APPARATUS.

THE INDIRECT HEATING OF WATER.

THIS mode of heating might more correctly be described as "heating water by hot water," and the particular end that it serves is to get water heated by a fire, yet to prevent the water which is required for use receiving heat from the fire in a direct manner. The chief advantage claimed for indirect heating is in preventing boilers becoming incrusted, and pipes choked, with lime deposit.

It is recognised that the presence of lime in boilers is due to three things, the absence of any one of which will prevent the lime deposit occurring. The three things are (1) the water having lime in solution, this being what is known as "hard" water; (2) the water must reach a high temperature; and (3) the water must be frequently changed.

The last of these things is perhaps the most important, as the hardest water does not cause a visible deposit of lime, if only one volume is heated; but by continually drawing water from taps, and as continually changing the water in the boiler, the lime then forms a substantial coat on the boiler-plate in a rather short time. When heating indirectly, the water heated by the boiler is seldom changed, and thus the lime deposited from it cannot be sufficient to cause trouble. The second necessary phenomenon in the deposition of lime—the high temperature of the water—has also no injurious effect in an indirect apparatus, as the water that is drawn, and is being continually changed, does not reach a temperature much above 140°; and as the lime is not precipitated until the water is near or at boiling-point, it will be seen that the "fur" trouble is overcome.

Fig. 229 will afford an idea how the indirect heating is usually attempted, and this illustration will also serve to show how it may fail. In the first place it will be plainly seen that the boiler, whatever its kind, must be as effective as if water was directly heated in the usual way. For instance, if there were a bath and three to four other taps to supply, the suitable size of cylinder would be 50 gal., and it would require a boot boiler behind an 11-in. or 12-in. fire to make the whole effective. If the heating has to be done indirectly, the boiler cannot, of course, be any the less powerful, as it has not only to heat the 50 gal. in the cylinder, but also to heat the contents of the coil, or whatever form of heater is placed in the cylinder, while the barrier between the two waters tends to make results slower.

Assuming, therefore, that a suitable size of boiler exists, what is to prevent its overheating the small quantity of water held by the coil, causing it to boil furiously, giving trouble by ejecting water from its expansion pipe, and making alarming noises? If it does boil frequently it will introduce another fault in evaporating so much water that there will be a continuous change of water in the boiler, and lime will be deposited there. (Range boilers used for steam cooking fur as badly as hot-water supply boilers, as the loss of water in the form of steam requires the cold feed to be continually making good the water that is evaporated.)

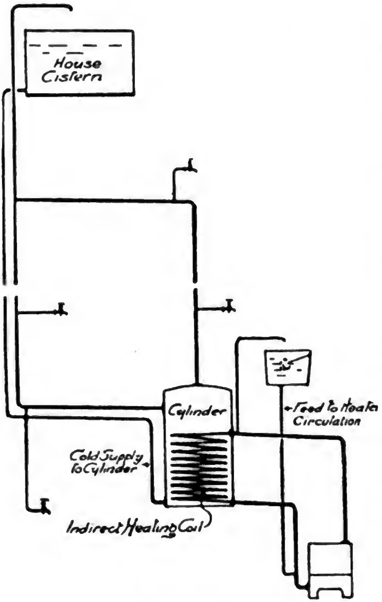

FIG. 229.

To overcome the possibility of the boiler-water reaching boiling-point, the coil or heater in the cylinder must have a surface area fully large, so that the heat loss from it is sufficient to keep the water in the coil below boiling-point. It will be understood that if the coil is large enough it can be robbed of heat, by the water surrounding it, almost as fast as the boiler receives heat, and by this means the boiling of the boiler-water is prevented until the whole contents of the apparatus approaches that state. This latter is not likely to happen, as the demand for hot water at taps is such as to seldom allow very high temperatures to be reached in a domestic hot-water apparatus.

There is another reason for having the coil, or heater large; this being to allow for the fact that water cannot be heated by hot water nearly so fast as it can be heated by a fire. It has to be remembered that the water in the cylinder, for domestic use, is only heated by hot water; that is, the heating medium, at its hottest, is only about 200° F., which is far below the red heat of the fire of a kitchener. It follows, however, that if the total heating surface of a boiler is, say, 3 sq. ft., we can hope to get the cylinder-water to absorb about an equal number of heat units as the boiler-water does, provided the heater coil is made proportionately larger.

The heat of a kitchener fire averages about 1300° F. (when burning hot and fast), but the whole of the boiler heating surface does not touch the fire, nor does one-third of it, as a rule. It may, therefore, be roughly estimated that the average of the boiler heating surface, when the damper is open, has an 800° F. temperature acting on it, and the area of coil surface for indirect heating should be based on this difference.

In a paper on this subject read before the Institution of Heating and

Ventilating Engineers, the author gave figures, based on calculations of heat transference, showing that the indirect heater should have a surface area three times as large as the heating surface of the boiler. In the writer's opinion this is not sufficient, for an index to efficiency in any domestic hot-water supply apparatus is the speed with which hot water can be obtained after lighting the fire in the morning. A pre-breakfast bath, 30 gal. at 100° F., one hour after lighting the fire, must be given, if an apparatus is to be considered efficient, and to secure this the indirect heater should have four times as much surface as the boiler, while five times will be found better still. The boiler should also be about one-fifth more powerful than if direct heat was being used in the ordinary way.

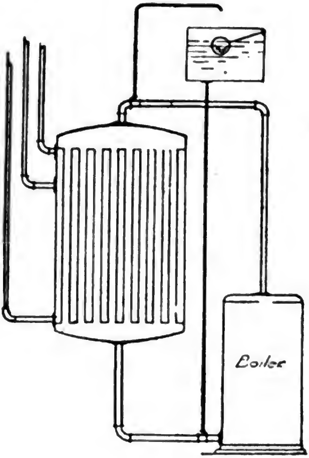

FIG. 230.

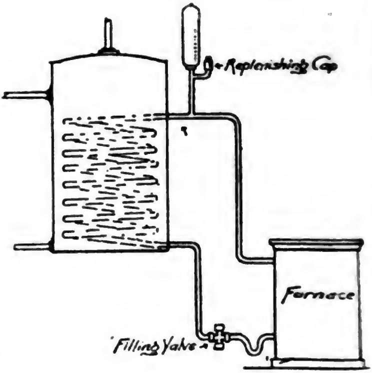

FIG. 231.

A pipe-coil is possibly the most convenient form of secondary heater, but the thickness of the metal of which iron tube is composed might with advantage be reduced. A copper tube of comparatively light gauge will afford much better results; but when the apparatus is at all extensive, the cylinder and secondary heater might be made together, something like Fig. 230. A coil has the disadvantage of having its effectiveness reduced as its length of pipe increases. It will be seen that as the hot water from the boiler enters the coil, this water immediately commences to lose heat in its passage through the coil. It is therefore easy to imagine that after passing a certain distance through a coil the water from the boiler is so reduced in temperature as to be practically useless as a heating agent. On this account coils should be limited to about 30 ft. of pipe, and even this length must have its return end rather cool when first heating up in the morning with the surrounding water cold. With a multitubular heater, as Fig. 230, the required length of tube can still exist, but it is divided up into short lengths, so short as to be of practically full temperature from end to end, and the resulting efficacy is improved accordingly. Such a heater as Fig. 231 would be used in conjunction with an independent boiler.

When an independent boiler is to be used, it is worth consideration whether a high-pressure installation should not be adopted. With this, the temperature of the water in the heating coil can be very high, and on this account, and the high velocity of the circulation, a coil heater is not to be objected to in the manner just stated. Fig. 231 will give an idea of this, and it will be seen that there are no risks of annoyance by the primary heater (the boiler) overheating and boiling, and a feed tank is not required to this part of the apparatus. A little water filled into the replenishing cap about every two months will keep the high-pressure section served in this respect. As the water in high-pressure pipes can be kept at any required temperature between 350° to 400° F., its effectiveness, for heating purposes, exceeds that of steam. (By F. Dye, in the 'Plumber and Decorator.')

* * *

HYDRAULIC RAMS,

FIXING AND WORKING.

(*See also* PUMPS, WATER SUPPLIES TO COUNTRY HOUSES, ETC.)

Note.—For other tables and calculations used in finding the working efficiency of hydraulic rams, *see* "WATER SUPPLIES TO COUNTRY HOUSES."

The hydraulic ram is an appliance operated by a fall of water, the power thus obtained being utilised to raise a proportion of the water to a height considerably above that from which it first fell, and this water can be delivered a considerable distance from its source.

The fall of water required to operate the ram may be from 2 ft. to 30 ft., but a high degree of efficiency cannot be expected from very low falls; while, on the other hand high falls are objectionable as causing excessive wear and tear. The ideal fall is about 10 ft., and most engineers hesitate to use a fall exceeding 20 ft. It might be said that there is no reasonable limit to the work, a ram will do either in quantity of water and distance of delivery. There are known instances of water being thus elevated 800 ft., in quantities up to 200,000 gallons a day delivered two miles distant.

(*a*) Fig. 232 illustrates, in section, Keith's patent hydraulic ram, and the following is a description of its parts: L, inlet from drive pipe; I, brass-lined cylinder in which dash valve works; H, dash valve; K, outlet for waste; A, air pipe or snifter valve; B, inner or air vessel retaining valve; G, air vessel; M, discharge cock for enabling the air vessel to be emptied of water and recharged with air when necessary; N, delivery outlet; C, D, E, F, counterbalance gear (when necessary) for very low falls.

The action of the ram (and this illustration will serve for a general description) is that the water from a stream coming down the drive pipe and entering the ram at L, instantly passes through I towards the outlet K, but in its rapid passage through it carries up the dash valve H, and closes the opening, as is shown in the illustration. As the dash valve closes sharply, there is a sudden pressure or shock experienced in the body of the ram, and this lifts the valve B, allowing some of the water to pass up into the air vessel G. This relieves the sudden pressure exerted, with the result that the dash valve falls again, but only to be carried up again by the passage of water, and as it closes so is the shock repeated, which gets relief by some more water being driven through B. This action is rapidly repeated, thirty strokes a minute being an ordinary number, and the supply of water passing into the air vessel is satisfactory, though not so much as goes to waste past the dash valve and through the outlet K.

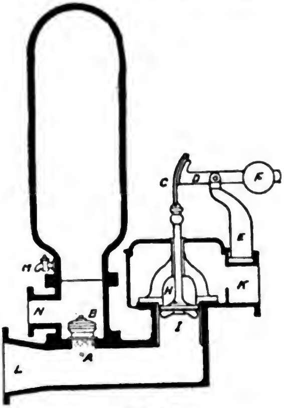

FIG. 232.

As the water enters the air vessel G, so it passes out and up through the delivery pipe. As this water rises high in the delivery pipe, the back pressure on each stroke is considerable, and the air vessel fulfilling the same duty as it does on a pump, prevents shock and injury to the apparatus. The air will sometimes be absorbed, or work out of the air vessel, and whenever it does, the noise and vibration give the plainest evidence that the elastic air cushion is dwindling away. It might be said that the air is always being absorbed from the chamber, and an inlet is provided expressly to make good this loss. As a rule it is a "snifting" valve (at A on the illustration), this being a plain piece of metal tube with a very fine hole through it. Keith's rams, however, have a properly constructed air valve which it is claimed gives a more regular supply to make good the loss.

A feature also peculiar to this ram is the counterbalance gear, illustrated and marked with the letters C, D, E, F. It can be well understood that with an unbalanced dash valve there is considerable resistance offered to its rising freely with a low fall and limited supply, the result being that much more water goes to waste than when the valve lifts with very little force beneath it. The counterbalance gear provides for the dash valve lifting with a low force as will be seen.

Fig. 233 affords a clear idea of the detail of piping required in fixing a ram. It is not essential that the drive pipe be taken from the exact head of the fall. It may come from any point in the higher point of the stream, the fall required for the operation of the ram being in the drive pipe.

(*b*) A ram of good make will generally raise water thirty times the height of the fall, but in practice it should not be given more than about twenty-five times the height, and the total height ought not to exceed 200 ft. An authority states that when driving water to a house or reservoir 1000 ft. from the ram, the latter, if of good make, will raise $\frac{1}{7}$ part of the water passing through it to 4 times the height of the fall, $\frac{1}{14}$ part 8 times, and $\frac{1}{28}$ part 16 times the height of the fall. Thus a ram with 8-ft. fall will raise 1 gal. 64 ft., or 2 gal. 32 ft. high, out of every 14 gal. passing through the ram.

Although some figures may be furnished as to the sizes of drive and delivery pipes, about the best plan to follow is to let the ram-maker furnish these particulars. In ordering a ram it is necessary to state (1) the utmost available fall; (2) the amount of water running in the stream; (3) the height to which the water is to be raised; (4) the amount of water required per day; (5) the horizontal distance from the ram to the cistern or reservoir. A list which will be found of some service, when the conditions are what may be termed ordinary, has been published by Hughes, Sutton, and Digby, Ltd., as follows :—

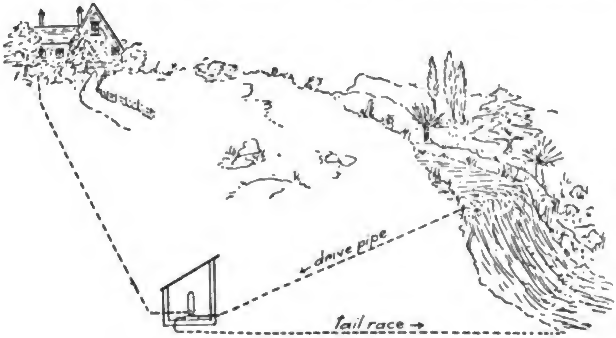

FIG. 233.

Diameter of Drive-pipe.	Diameter of Delivery-pipe.	Quantity of water available in gal. per min.	Approximate Number of Gal. raised in 24 hours.	
			60 ft. high.	100 ft. high.
in.	in.			
1	⅜	1 to 4	200 to 800	100 to 400
1½	½	4 „ 10	800 „ 2,000	400 „ 1000
2	¾	10 „ 20	2000 „ 4,000	1000 „ 2000
2½	1	20 „ 25	4000 „ 5,000	2000 , 2500
3	1¼	25 „ 30	5000 „ 6,000	2500 „ 3000
3½	1½	30 „ 40	6000 „ 8,000	3000 „ 4000
4	2	40 „ 60	8000 „ 12,000	4000 „ 6000

Ordinary conditions would mean a fall proportionate to the height of delivery—1 to 25—and a horizontal distance of 250 yd. to ½ mile.

A formula given by Eytelwein for the diameter of the parallel drive pipe is that the square root of the quantity of water used in gal. per second is multiplied by 0·058. The delivery pipe should have a diameter that will not add more pressure (by friction) than is equal to a head of from 2 to 3 ft. This would usually make it ¼ to ⅓ the area of the drive pipe.

Another formula to find the diameter of the drive pipe is—for the diameter of the drive pipe, multiply the square-root of the number of cub. ft. of water used per second by 1·45. For the delivery pipe, multiply the square-root of the number of cub. ft. of water used by the ram by 0·75.

The length of the drive pipe of a ram has an important bearing on the efficiency of the apparatus. On reference to Fig. 232, it will be seen that the sudden stoppage of the flow of water through the dash valve (also called the pulse valve) and the shock or ramming stroke the water then delivers, not only opens the valve B but also exerts an equal pressure backwards on the water in the drive pipe

The flow of water down the drive pipe is arrested for the moment, and if this pipe is too short, the flow will be reversed—the water being driven back—and this would cause irregular working. Attempts have been made to overcome this—and admit of a short drive pipe—by putting a check valve (flap valve) just where the drive-pipe joins the body of the ram. This would shut against any back pressure, quite obviating any reverse action in the drive pipe. This, however, has proved such a limited success, that every engineer arranges to have a drive pipe of sufficient length to make a check valve unnecessary. It is less important that the drive pipe be long when the fall is a good one and the delivery is moderately low, than when the fall is low and the delivery a full height. On this account, no length can be given that will suit every case.

To decide the length of the drive pipe an authority has stated that its length should be as great as the height to which the water is to be delivered, or, at least, ¾ of this. Another calculation requires the length of the drive pipe to be 16 times the fall, without considering the height of the delivery. American practice is to allow the length to be 5 to 10 times the fall. A good plan is to put the available figures before the maker of the ram, and let him decide. As no two makers of rams act quite alike the maker is undoubtedly the best judge of his own appliances. Failing this the best rule to follow is the first one given, which provides for the drive pipe being in length the same as the perpendicular height from ram to cistern, with a minimum of 30 ft.

The drive pipe is usually of cast or wrought iron. This has not such a smooth interior surface as lead pipe, but this latter does not bear water-hammer, or strain due to shocks, well.

In fixing a ram the first thing to be done is to form the base it is to stand upon. The ram should be placed on a slab of stone, 6 in. or 8 in. thick, and be bolted firmly to this. The stone is cemented on and into a concrete bed. The ram must be fixed quite level. With low falls every effort is made to get every inch of depth possible, to increase the fall to this extent, but, of course, the ram cannot be placed so low that the tail water will not flow away. Some rams will certainly work when submerged a little in times of storm and flood, but this is not a normal state of things, and the rams cannot be giving best results.

The distant or stream end of the drive pipe has a strainer over it to prevent fish or other living things getting into the ram, and this should be accessible for cleaning. It is important that the drive pipe be joined very soundly to the body of the ram, this joint being the most likely one to work loose and give trouble.

It is a good plan to provide a stop valve (with full straight way) at the foot of the delivery pipe, that this pipe may not have to be emptied when the ram needs attention. On the other hand, an emptying cock might be provided at the foot of this pipe—on the delivery side of the stop valve to admit of the pipe being emptied in times of severe frost or for other purpose.

If, on completing the fixing, a test is made and the ram does not immediately work, it may be found to operate properly if the dash or pulse valve is pressed down, from the top, with the foot and worked up and down a few times. The number of beats this valve may make per minute depends on the distance the valve rises in making a beat. It will be found that in the make of the ram provision is made to regulate the travel of the dash valve and the consequent number of beats.

(*c*) The equation used for working out hydraulic ram duties is : $Q \times H = q \times h$, in which Q = the quantity of water flowing through the ram in gal. per minute ; H = head, or height in feet of the drive water above the ram ; q = gallons raised or delivered per minute ; and h = height in feet to which the water is raised.

Let a case be assumed as follows: A spring is available yielding 25 gal. of water per minute, 60 ft. below the house and 350 ft. from it. A fall of 12 ft. can be got from the spring to a lower point. 300 gal. of water per day is required. This being the case, it may first be concluded that the 12 ft. available fall will only be 10 ft. actual, when the ram is connected up. The total height to which the water is to be raised will probably be 60 ft. × 10 ft. ram below spring + say 30 ft. height of reservoir or tank in the house above ground level, or say a total of 100 ft. In these conditions the actual duty of the ram will be about 40 per cent. of the theoretical duty. Then to raise 300 gal. per day of 24 hr., or

$$\frac{300 \text{ gal.}}{24 \text{ hr.} \times 60 \text{ min.}} = 0{\cdot}208 \text{ gal. per}$$

$$\text{min., } Q = \frac{{\cdot}208 \times 100 \times 100}{10 \times 40} = 5{\cdot}2,$$

or say, nearly 5¼ gal. per min. must pass into the ram. This yield will exceed the amount required. The A size of ram would be sufficient, with 1 in. drive pipe and ¾ in delivery. The lift of 100 ft. will require the drive pipe to be 150 ft. long. It is important that drive pipes and delivery pipes (also tail-water pipes) have a gradual and true fall or rise, otherwise air will collect in them and cause considerable trouble. (J. Wright Clarke.)

The simplest method of calculating the amount of work which may be expected of a ram is to consider, on the one hand, the amount of flow energy available to do the work ; and on the other, the amount of work to be done. The latter must include all power used in working the ram, and also loss by friction, etc., for which it is usual to add one-third to the actual work to be done. It is found in practice that an average efficiency of the working of a ram is 66 per cent., the other 34 per cent. being absorbed by friction of working parts and to give the necessary excess of power over work to be done. A useful formula is $Q \times H = q \times h$, in which

Q = quantity of water used (or flowing down the drive pipe) in gal.
H = head of drive water in ft.
q = quantity of water raised in gal.
h = height to which water is raised in ft.

Therefore

$Q \times H$ = ft.-gal. of flow energy to do the whole of the work.
$q \times h$ = ft.-gal. of work to be done.

This rule may be transposed to find any one of the four factors when the other three are given, care being taken to add or subtract the ⅓ as required. Thus, gal. raised, or

$$q = \frac{H \times Q \times 2}{h \times 3} = \text{gal. raised.}$$

Or to find quantity of drive water required—

$$Q = \frac{q \times h \times 4}{H \times 3} = \text{gal.}$$

required to flow down drive pipe.

If in practice a large head of drive water can be obtained, the drive pipe should be proportionately shorter, and if a small head, then a longer drive pipe is necessary. The head should not exceed 12 ft. to 15 ft. for ordinary purposes. (Hy. H. Clay, in the 'Plumber and Decorator.')

(*d*) Among the many instances of great advancement made in the construction and efficiency of plumbing devices, the improvements made on the hydraulic ram should not be overlooked. Indeed, the modern type of ram is so far perfected, and is capable of accomplishing such large results that the name hydraulic engine now often applied to it has become an appropriate title. We show sections of one of these modern devices, in the accompanying illustrations, the one shown being the Rife hydraulic engine, but there are other engines or rams on the market capable of excellent work.

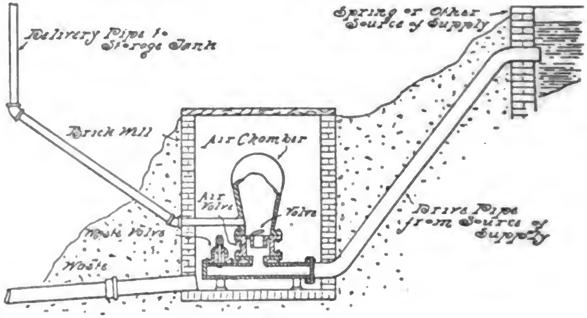
Delivery Pipe to Storage Tank
Spring or Other Source of Supply
Brick Wall
Air Chamber
Air Valve
Valve
Waste Valve
Waste
Drive Pipe from Source of Supply

FIG. 234.

Fig. 234 is a sectional view of the Rife single acting ram or hydraulic engine, the action of which is briefly as follows. When the waste valve is open, water entering the ram through the drive pipe from the source of supply, escapes through the valve opening until the pressure due to increased velocity of the water becomes strong enough to close the waste valve. At the instant that this valve closes, the impact from the body of water flowing down through the drive pipe produces a shock or ramming stroke as it is called, which opens the valve at the bottom of the air chamber.

The entrance of water into this chamber compresses the air contained in it, and this compression continues until it is great enough, together with the pressure in the discharge pipe, to overcome the momentum of the water flowing through the drive pipe. There will be an instant at which the two forces balance each other, which is followed by the preponderance of the pressure from the air chamber over that due to the head of the water in the drive pipe, owing to the fact that the latter has lost the force of momentum which it had when in motion. The greater pressure within the air chamber closes the inner valve, and the motion of the water in the drive pipe is reversed. When the water below the waste valve and in the drive pipe moves in a backward direction, it will be clearly seen that a partial vacuum forms below the waste valve, causing the latter to again open. When the valve opens, the water from the drive pipe rushes in again, and thus the operation continues.

When the valve inside the air chamber closes, the pressure of the air forces the water out of the chamber, up into the discharge pipe, to the point of delivery. At the instant when the tendency to a vacuum exists, air enters the apparatus through a small valve at just below the air chamber, and finds its way at the next stroke, into the chamber. This is an important provision, for otherwise, as the water in leaving the air chamber takes with it each time a small amount of air, the air chamber would after a time become exhausted of its air, and the apparatus fail to work.

A counterweight on the lever arm allows the adjustment of the waste valve to different heads and lengths of the drive pipe. The weight should be so adjusted that the valve nearly balances, and when this is done, the valve will seat very quickly.

The result of the quick seating of the waste valve is that the ram makes a large number of quick, short strokes, such strokes not only being far easier on the apparatus than long, slow strokes, but performing the work with far less waste of water.

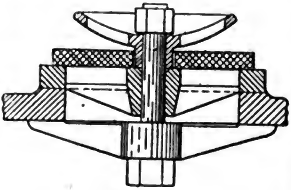

FIG. 235.

It goes without saying that the stroke must have power enough in it to overcome the pressure in the delivery pipe, the proper placing of the weight allowing this to be done to a fine point. The waste valve consists of a large rubber valve acting with a balance counterweight and spring seating, which results in taking up almost the entire jar when the valve closes. The valve inside the air chamber we show in detail in Fig. 235. It is made up of a rubber disc, with gridiron ports and convex seats fastened at the centre and lifting on the circumference. The result is that the shock from the driving water is transferred through the air cushion with the least possible jar and friction.

In Fig. 236 we show the double acting type of this same engine, the only difference between it and the single acting type being the connection just below the air chamber valve.

It sometimes happens that the supply of water which it is desired to use is somewhat limited, and in this case, if another supply is at hand that may be used to operate the ram, the latter may be used for power, and the former may be delivered. The double-acting ram is designed to accomplish this result, the general idea of the connections being shown in Fig. 236.

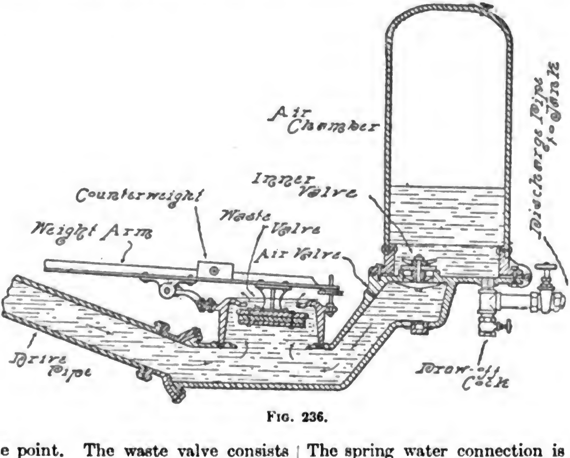

FIG. 236.

The spring water connection is made as seen in Fig. 237, and by properly adjusting the relative flow of the water used as power, and the water to be delivered, spring water for instance, the ram may be made to deliver only the latter. The old style ram claimed to deliver when properly installed about one-seventh of the water issuing from the source of supply to a height five times as great as the distance from the source to the waste valve, or one-fourteenth of the water to a height twenty times this distance. The makers of the ram which we have described, however, claim that it will pump water 30 feet high for every foot of fall on the drive pipe, and at a much lower rate of water waste. That the apparatus covers a wide field may be seen from the fact that they are made of various capacity, from the small sizes to those capable of pumping 1,000,000 gallons per day. The claim is also made that they will pump as high as 500 feet.

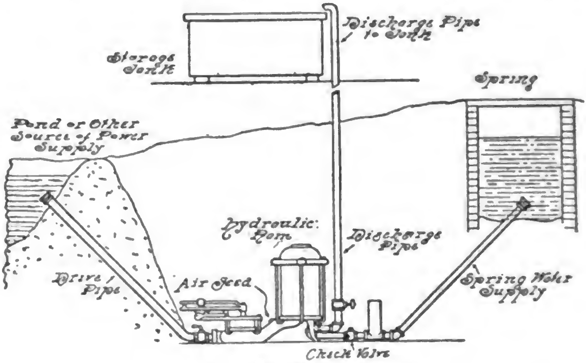

FIG. 237.

In the use of the ordinary ram it is best to use as small a head as possible, owing to the severe shock on the apparatus, due to a high head. In the use of the present device, however, it is claimed that it will work under as high a head as 50 feet, and under as low a head as 18 inches.

The delivery pipe from the ram to the tank should generally be of about one-half the diameter of the drive pipe. When the perpendicular fall from the source of supply to the waste valve is only a few feet, and the water is to be raised to a considerable height, the length of ram, that is, the length of the drive pipe, must be increased to such an extent that water in it will not be forced back into the spring when the waste valve closes, which result will occur, if the drive pipe is not long enough. The proper laying of the drive pipe is an important feature to the successful operation of the ram, some of the important points being as follows: The drive pipe should be run on an incline perfectly straight. The only curve this pipe should have is at the point where it connects with the ram, and the change in direction should be made by bending the pipe rather than by the use of fittings. The end of the drive pipe entering the source of supply should be provided with a strainer, and should be low enough in the water to avoid any possibility of drawing in air. In addition it should be seen to that the drive pipe is absolutely air-tight.

In many cases, owing to the relative

positions of the ram and the source of supply, and owing to the nature of the surface of the ground, it is very difficult without digging deep into the ground to run the drive pipe on a single straight incline to the ram, and to overcome this difficulty, several expedients may be resorted to. Two of these remedies we show in Figs. 238 and 239.

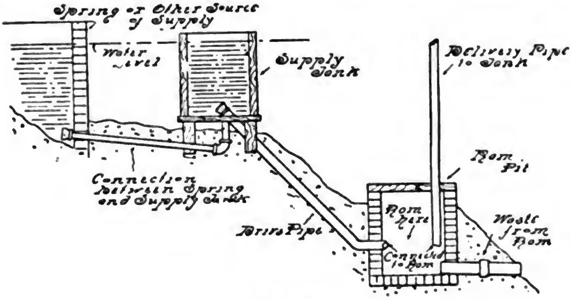

FIG. 238.

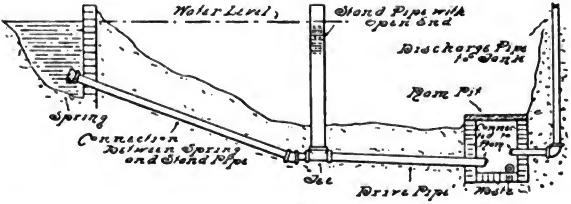

FIG. 239.

In Fig. 238, a tank is located between the source of supply and the ram at such a point as conditions may make advisable, and the water carried from the source into the tank. The water stands at the same level in the tank as in the spring, and from the point at which the former is located, the drive pipe may easily be run to the ram in the proper manner.

In Fig. 239, the same result is accomplished, possibly at less expense, by the use of a stand pipe in place of the tank, although instead of constructing a tank especially for the purpose, a stout barrel may be used. ('The Plumbers' Trade Journal.')

INCUBATORS.

TAKING into consideration the number of conditions absolutely necessary, a home-made, roughly constructed incubator is not likely to be successful. A machine which automatically regulates the temperature of the eggs, irrespective of that of the external atmosphere, is essential. Regulators are attached to all incubators in use at the present time. Tomlinson's works by the expansion of air; Christy's by the flexing of a compound metallic bar, and Hearson's by the volatilisation of fluid in a metallic capsule, which, by its sudden expansion at any desired temperature, cuts off the source of heat, and prevents the degree to which the machine is regulated being ever exceeded. In addition to the exact regulation of the temperature, an incubator, to be successful, must be so arranged that the eggs are heated from above, and that there must be a constant supply of fresh, moist air (not saturated with watery vapour). The advantages of incubators from a practical point of view as regards market and table poultry are due to their supplying hens with full clutches of chickens. In France, chickens are hatched in large numbers for sale to small proprietors, and reared by them under ordinary fowls, or in larger numbers under turkey hens. There need be no hesitation in using incubators on the score of practicability, as the product—the chickens—are found to be as satisfactory in every way as if naturally hatched under a hen.

Incubators have been of two general types, viz., the "atmospheric" and the "hydro"; these terms, simply explained, being that the former has heated air and gases direct from the burners to afford the required warmth, while the latter has a hot water tank (heated by burners) to yield the warmth. The opinion of experienced people is that one is as good as the other, given equal care in the make and use of the incubator, but Hearson's patent (1881, now expired) having been of the hydro variety and largely advertised and pushed, has made this principle the one most in favour and use.

The sizes of incubators usually run 25, 50, and 100-egg. There is a general opinion that they work best when full, and that a 100-egg size with 50 eggs in it does not give such good results as a 50-egg size with 45 or 50 eggs in it.

The essentials of incubation are a uniform temperature, applied from above the eggs, and a regular supply of fresh air which must be humid or moist, but not positively saturated. It is required to prevent the eggs being dried by the warmth, but too much moisture is almost as bad as a want of it. The temperature required is 104°F., but it may vary a degree either way, though every care should be taken to adjust the regulator to get precise results. Every incubator should be run a day or two empty before the eggs are put in to get correct adjustment. The temperature is ascertained from the thermometer shown in the illustration. This should be a plain tube with long bulb and graduated from 90° to 110°F., the marks being on the tube itself, not on paper or wood attached to the tube. A second thermometer graduated to about 160°F. is sometimes used to test the heat of the water, but this is optional, as the heat in the egg drawer is the important temperature. When putting the eggs in let the temperature be low rather than high, and a comparatively low temperature for the first few hours is much better than heating them up rapidly and possibly overheating them in doing this. Experienced people consider that more eggs are spoiled during the first twenty-four hours than any time. It may be added that there is no necessity to cool the eggs a little once a day, as a hen does, when she vacates the nest to feed. It is unnecessary trouble, and there is considerable risk by forgetting them for an hour. Constant regular heating is in every way successful. Incubation lasts from 20½ to 21 days.

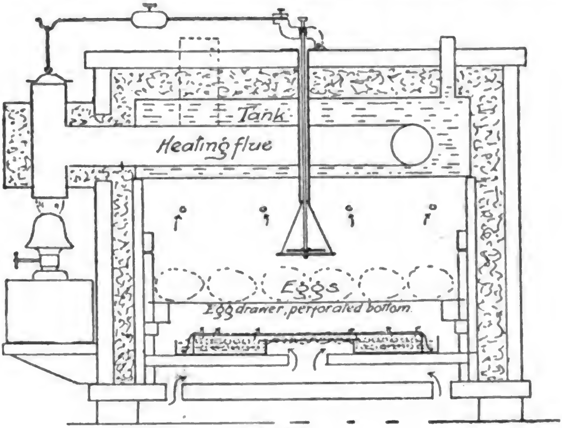

FIG. 240.

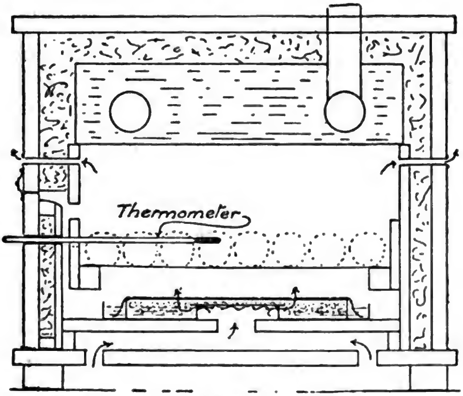

FIG 241.

The following illustrations, Figs. 240 to 244, afford particulars of a successful incubator of the water-tank or hydro type. Fig. 240 is a cross section from side to side; Fig. 241, from front to back; Fig. 242, addition of drying box, if required; Fig. 243, the finished incubator showing front flap door down and egg drawer partly out; Fig. 244, details of air-humidifying tray. The incubator consists largely of an outer and inner wooden case, the space between the two being packed with a poor heat-conducting material to prevent loss of heat, or changes of internal heat due to changes in external temperature. Cow-hair is a good material, as being almost devoid of heat-conducting properties, but this is liable to harbour vermin, if they can get to it. Sawdust is fairly successful, but these and many other substances possess the disadvantage of being inflammable. There is risk of their igniting where the flue passes through, and on this account and for general reasons, silicate cotton (slag-wool or glass-wool) should be used, if it can be obtained. It is reasonable in price, a good poor-conductor, and is quite non-inflammable. Failing this, sand is successful, but not easily packed or held in place everywhere. To avoid risk of fire, the tank is sometimes extended as a water-way tube around the flue just where it enters.

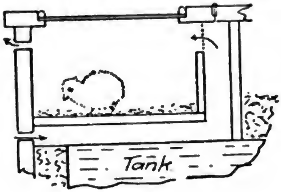

FIG. 242

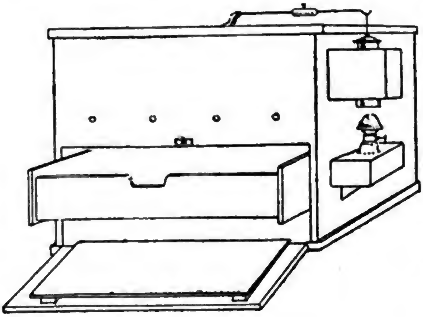

FIG. 243.

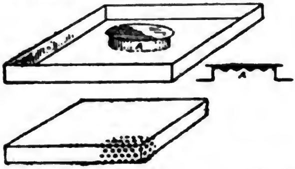

FIG. 244

The tank, it will be seen, has its contents heated by the flue passing through. The flue enters at the side, near the front, passes along the front, then goes from front to back (still horizontally in the tank), then from side to side along the back, lastly rising as a short vertical pipe, as shown in dotted line in Fig. 240. A plan of the flue in Fig. 240 would show it to be ⊃-shaped, wholly in the tank except the end that receives the heat and the end which discharges the products of combustion. The tank has a filling tube, at a convenient point on top, as shown. The heat is best afforded by a petroleum lamp with a Silver's burner, this requiring no glass chimney, but any burner will do, if it burns regularly, brightly, affording a good heat and not smoking.

The egg-drawer has a bottom of perforated zinc or wire gauze, and beneath this comes the air-moistening or humidifying tray or pan. This is shown in detail in Fig. 244, and will be seen to consist of a square zinc tray with a low "tower" in the centre, this tower being perforated all round just beneath its upper plate. Reference to the other illustrations will show that all the air comes through these openings. Resting in the tray, over the "tower" is an inverted tray made of perforated zinc, shown separately as the lower half of Fig. 244. When this perforated tray is in position, it is covered with a piece of canvas or similar absorbent material cut a few inches larger than the perforated tray, so that its edges may fall down and dip in the water that is in the lower and outer tray. This is shown in the first two illustrations and the result, it will be seen, is that all the air that passes the eggs has first to pass through a sheet of material saturated with water. The humidifying tray rests on a wooden false bottom, as shown.

The temperature is recorded by the plain tube thermometer which is shown passing through a felt-lined hole in the front flap door in Fig. 241. The outlet ventilation is provided by four simple holes at front and back, as shown.

Probably the most important detail of an incubator is the temperature regulator. It will be seen that there is a metal cap suspended over the vertical flue tube which is immediately above the lamp. If this cap is close down on the tube, the whole of the heated products from the lamp have to pass through the flue which traverses three sides of the tank and the water receives its greatest heat. If, on the other hand, the suspended cap does not come down close on to the vertical tube, then a certain amount of heat escapes, the amount corresponding to the extent of the opening between tube and cap. If, therefore, heat escapes this way it is lost to the tank, and the heat of the water is less accordingly. The purpose, therefore, of the regulator is to so control the volume of heated products passing through the tank flue that the water shall be kept at a uniform heat, and thus afford a constant uniform warmth to the eggs.

The motive power that operates the suspended cap (by means of the horizontal lever rod shown) is a "capsule," or what the Americans call a wafer. It is a flat hollow disc of thin sheet brass, with flexible sides, so that any pressure from within the capsule presses or bulges the sides outwards, that is, causes the otherwise flat disc to swell its sides out to form a ball as far as it is possible for it to do so. It is not intended to recommend that any amateur attempt to make the capsule, as it would mean special apparatus and numberless trials before a perfect one was obtained. A single capsule, or two or three, should be bought, but it may be explained that within the capsule there is a little special fluid, usually a mixture of alcohol and ether, that evaporates—it might be said, boils—at a low temperature and generates vapour or steam in sufficient volume to press out the walls of the disc.* Here, then, we have a small appliance that affords a movement by the inflation and deflation, according to the temperature.

The capsule is placed horizontally just above the eggs, and to admit of its operating the vertical wire rod which rests upon it (Fig. 240), and so raising or lowering the flue cap, it (the capsule) must rest on a firm bracket or base. This is provided by a hanging bracket or table, a plate suspended by rigid wires, as shown. On this little table the capsule rests, and, when it inflates, being unable to inflate downwards, it does so wholly in an upward direction, raising the vertical rod accordingly. By shifting the small weight shown on the top horizontal bar, the action may be "set," so as to correspond exactly with the required temperature.

It may be added in conclusion that an incubator requires to be carefully and well made, as, failing this, many faults will develop, the results of which will be perplexing, and probably set down to the quality of the eggs, or failure due to the hatching being "unnatural." It is of no use anyone just knocking one together to see if it answers, for the probabilities are that it will not. Of the parts that require to be particularly accurate, the operation of the temperature regulator perhaps takes first place. It is the fitting of the capsule, its base or table and the vertical rod from it that have to be really good work, as the vertical rod must not bind anywhere in its tube, and it must be truly vertical and come down precisely central on the capsule. The pivoted fitting at the top, which the upper end of the vertical rod elevates, must also be accurate in its movement. Occasionally it is hinged, a pin passing through its knuckle, but it is better to let it be pivoted on two pointed set screws, one each side as Fig. 245.

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* Though the capsule is spoken of as a disc, it may be square, say 2 in. by 2 in.

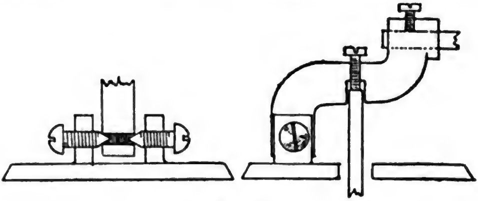

FIG. 245.

* * *

INDIA-RUBBER.

(*See also* CEMENTS, EBONITE AND VULCANITE, GUTTA-PERCHA, RUBBER STAMPS, ETC.)

CAOUTCHOUC or india-rubber, also briefly called "rubber" is a natural resin or gum that can be made to flow or exude from certain trees and vines, its fluid state changing to that of a comparatively dry, but very elastic, mass after exposure to the air. Originally it was thought to be the product of but one kind of tree, but the great demand and the high value of rubber have resulted in many vegetable growths being found to yield the precious fluid. Some are trees, some shrubs, while much of the African rubber is procured from the *Landolphia* giant vine or creeper in its varieties. There is scarcely a country in the tropical belt that does not now send rubber into the market. Some rubber juices dry in the sun, while some require astringents or smoking. There are now also bastard rubbers to be reckoned, there having already been found some scores of trees that yield a gum that resembles true rubber more or less. Balata, for instance (the gum of the bullet tree), is so nearly a true rubber as to have considerable use in the arts in lieu of rubber, for being a substance intermediate between rubber and gutta-percha it may be used for insulation work and many manufacturing purposes where an inferior rubber answers all requirements. There are, however, bastard rubbers that have little utility, except as adulterants and to show to what extents the search for these substances is carried it may be stated that, in Yucatan, a rubber-like gum is obtained from an insect that swarms in certain districts.

The caoutchouc or rubber of commerce is soluble in ether, chloroform, carbon bisulphide, coal-tar naphtha, benzol, turpentine, and in almost any liquid hydrocarbon; of these coal-tar naphtha is most largely used. Incorporated with solid hydrocarbons, as naphthalene, or paraffin, it behaves under the influence of heat in the same way as a true solution. It is insoluble in water, alcohol, and acid and alkaline solutions; but is rapidly acted upon by strong mineral acids, especially when heated, and by chlorine, bromine, and iodine in the cold. Heated above 4° C. (40° F.), it is soft and elastic, and remains the same at 100° C. (212° F.); below 4° C. (40°F.), it is hard and inelastic, but not brittle; when heated to 115° C. (239° F.), it softens, and is decomposed into a sticky, tarry mass by standing for a few days; congelation prevents this only while it lasts; heat accelerates the change. In this condition, however, it may be vulcanised. Contact with oily or fatty substances induces the decomposition of caoutchouc. In commerce, the manufactured article is usually called "rubber" or "india-rubber"; when cured or vulcanised, it is called "vulcanised rubber," if soft; and "vulcanite" or "ebonite," when cured to a hard or horny condition. Raw india-rubber as met with in the markets is technically called "gum." There are many applications, where the inferior kinds, irrespective of their being cheaper, are better adapted than the finer descriptions.

The preliminary treatment of all kinds of rubber is much the same as regards sorting, washing, and drying; there is, however, a great difference in carrying out the details of these processes, according to the nature or condition of the rubber, some descriptions having to be cautiously heated and dried, whilst others are much more easily manipulated. In selecting raw rubber, preference should be given to packages made up of small masses, or thin pieces, and to those samples which, when cut and squeezed, emit little or no moisture; bark and chips are more abundant in the drier kinds. The treatment of raw rubber, and the general subject of rubber manufacture, however, is so large a subject as to be outside the province of 'Workshop Receipts,' and the present article must be restricted to a variety of useful recipes.

Spreading and Waterproofing Fabrics.—The treatment of fabrics which are to be "proofed" by spreading, consists in passing them through a pair of calenders, with the object of pressing down knots, and giving a smooth and even surface; after this, they are passed over a steam-chest, to expel moisture, when they are ready to receive the first coat. This is usually a different mixture from the bulk of the proofing, and is called a "sticking-coat," its object being to secure adhesion between the fabric and rubber; it is generally incorporated with colouring pigments, white or black, so as not to allow the general mixture to show through the cloth, or alter its appearance. A little oxide of zinc, or whiting, is used for white or light-coloured goods; Frankfort and other blacks are used for dark goods. The coats, as applied, are dried by passing over a steam-chest, when the fabric is again brought to the front of the machine for another coat, and so on. Some descriptions of goods have a finishing coat of better quality or mixture, in some cases containing no sulphur, nor any pigment whatever. The number of coats varies from three to seven, according to the class of goods, and the weight of material which is to be put on.

Machines are now employed which work on the continuous principle; but as they require more space, so as to allow each coat to dry in time to receive another, it is not certain that there is much gain in using them.

Methods have been devised for collecting the naphtha vapour and condensing it; the principal objections to these arrangements are that they interfere with the workman's being able to see his work as it passes over the steam-chest, and do not allow the naphtha itself to pass off so completely, owing to the partial obstruction. The enormous quantities of naphtha which are dissipated in the spreading-rooms of some of the largest establishments, afford sufficient evidence of the want of some suitable means for this object. One plan which has been used, and which certainly does collect some of the naphtha, consists of a rectangular iron hood, of such dimensions as to cover the steam-chest, or the greater part of it, and raised towards the middle, where it opens into a zinc chimney or flue, and passes down, outside the building, into a receiver, kept cool by running water. The vapour is mixed with so much air, which passes away charged with the naphtha vapour, that it is only possible to collect a very small proportion of the latter. Bruce Warren's method has been used with greater success. Its peculiarity is in collecting the naphtha vapour by india-rubber, which is capable of abstracting solvent vapours from air charged with them. The air, loaded with the vapour, is made to traverse a series of trays containing laminated rubber, which is required either for solution or for dough; or the naphtha may be recovered by distillation, and the rubber be used over again.

Drying Spread Fabrics.—After the goods leave the spreading-machines, they are hung up for a few days in a warm room, so as to expel the little naphtha which is retained by the rubber, and which it gives up very slowly. This drying helps to remove the smell of the naphtha, and prevents blistering in curing. The quality of the solvent used, and the temperature of the drying-room, determine how long this "hanging up" must last before curing. As india-rubber licks up, as it were, the vapours and odours which float about in the drying-room, it would be infinitely better to have a series of drying-rooms, so as not to hang up the more recently spread goods with those which have more or less completely lost their smell of naphtha. Goods which are cured by the cold process are hung up in the same way; but as they have always a more disagreeable smell, they should have a separate hanging-room to dry in.

Preparing Fabrics for Curing.—When spread cotton goods have become tolerably firm, or quite dry, they are wound upon hollow sheet-iron cylinders, for curing in open steam, or in a steam-jacketed heater. As the condensed steam spoils these goods, they are carefully wrapped up as air- and water-tight as possible. Since wool and silk are destroyed by the heat necessary to cure india-rubber in this way, the cold process is the only eligible method of vulcanising. Very frequently, however, cotton goods are treated in the same manner.

In packing the goods for the steam-heater, care must be taken that the fabrics are wound without creases, and are not stretched, as the fibres of the cloth, after curing, will retain their distorted appearance. Double textures are simply wound up; but "surface" goods are first carefully brushed over with very fine French chalk, no excess or loose chalk being allowed to remain. They are then wound up; but, as this necessitates the rubber surface coming into contact with the cotton surface, whereby it is liable to be marked, it is more usual to run two pieces together, with the rubber surfaces against each other. This not only prevents marking, but secures an even surface; blisters, from dampness in the cotton, are also prevented.

Double textures are obtained by passing the proofed fabrics through a pair of rollers (the doubling-machine), whilst the surfaces are still sticky or adhesive; these are vulcanised, if required, by means of sulphur incorporated with the compounds, and steam-heat. The doubling-rollers are of solid cast iron, with turned surfaces, 6 ft. long. One is fixed, while the other can be moved by a lever, so as to admit the fabrics to be doubled. As they revolve in opposite directions, they draw the fabric through, and, when tightened up, press the two coated surfaces together.

Curing or Vulcanising.—When india-rubber is mixed with sulphur, and heated sufficiently, it acquires properties strikingly different from those of the original article. The tests which are now accepted as evidence of vulcanisation may be contrasted with the behaviour of unvulcanised rubber under the same agents:—

UNVULCANISED OR RAW RUBBER.

Heat.—Cannot be heated above 115° C. (240° F.) without decomposition setting in; if not at once visible, becomes very perceptible in a few days at most, especially on exposure to air or light. Heated to 118°–121° C. (245°–250° F.) for a little time, becomes soft and sticky, and finally is converted into a viscid liquid. Becomes quite hard at 4° C. (40° F.), and is readily softened by being held before a fire, or plunged into water heated to 21° C. (70° F.).

Stretching.—When stretched and kept drawn out for a little time, will retain more or less its elongated condition, and, if heated, will return almost to its original length.

Solvents.—Coal-tar naphtha dissolves it slowly, but soon renders its surface slimy and sticky. Other forms are more readily acted on by solvents, and yield in a few hours a gelatinous-looking mass. On evaporation, the rubber is left more or less sticky; by completely driving off the naphtha, the rubber is recovered either with its original properties unaltered, or perhaps a little soft. Inferior rubbers will remain sticky.

Roasting.—Quickly passes into a tarry condition, and emits a peculiar odour, not garlicky, nor sulphuretted. The uncharred portions quickly pass into an unctuous mass, after a short exposure to the air.

Sulphur.—Immersed in molten sulphur, it is converted into vulcanised rubber.

Uniting.—The freshly cut edges are easily joined by pressure with a little heat.

VULCANISED OR CURED RUBBER.

Heat.—May be heated above 115° C. (240° F.) without any visible change, and does not become soft or sticky if heated for hours at 121° C. (250° F.). Higher temperatures, as 132°–138° C. (270°–280° F.), continued for a few hours, may render some goods soft and clammy, which is regarded as indicating imperfect manufacture. No change is perceptible when placed in a freezing mixture, unless the rubber is imperfectly vulcanised. Water heated to 21° C. (70° F.) has no marked effect on its hardness. The effect of cold is more readily perceptible than that of heat on imperfectly cured rubber.

Stretching. — Should be perfectly elastic or nearly so. Imperfect vulcanisation is soon perceived by stretching, and measuring its increased elongation. Heat causes it to return slowly to its original length; if more thoroughly cured, it has scarcely any effect in this direction.

Solvents. — Unless highly cured, swells a little, but does not become sticky; if highly pigmented, it is rendered short and inelastic. It is not made sticky, unless under a very prolonged immersion, and heating. On evaporating off the solvent, the properties of the rubber are found unaltered, if of good quality.

Roasting.—Chars on the parts exposed to the heat, but does not so easily melt, and emits an offensive smell of garlic, which is modified by the proportion of sulphur. The uncharred portions remain unaltered if exposed to the air.

Sulphur.—Thoroughly vulcanised, is not affected, but more or less effect will be produced as the rubber is imperfectly saturated with sulphur.

Uniting.—The freshly cut edges may show a slight tendency to unite, but a joint cannot be made without proper appliances, especially if well cured.

Vulcanised rubber is obtained either by heating india-rubber mixtures containing sulphur, or by immersing india-rubber in sulphur or mixtures containing sulphur. Chloride of sulphur, iodine, bromine, chlorine, hypochlorous acid, sulphurous acid, chloride of arsenic, and a few other chemical agents, have an action on india-rubber approaching vulcanising. This "changing" of india-rubber was discovered by Parkes; it is now known as "cold curing" or "semi-curing." Chloride of sulphur is the only agent employed on a large scale. Warren's method of treating telegraph-wire has been already mentioned.

The present methods of vulcanising, which will be considered here, are: (1) when sulphur and a high degree of heat are employed—(*a*) the "water cure," where water heated by steam is the medium for heating; (*b*) the steam heater, where direct steam or a steam jacket is used; (*c*) hot air, or dry heat; (*d*) sand-bath; (*e*) high-boiling liquids; (*f*) sulphur, alone or in compounds, used in a molten state; (*g*) metals, either molten or heated surfaces. (2) Injecting hot air or gases, steam, water or other fluids, or metal, into the article to be vulcanised. (3) When little or no heat is employed, and chloride of sulphur and similar changing agents are used.

Circumstances arise where each of these methods is specially applicable; there is, however, a difference of opinion on the merits of some as compared with others where the same objects are to be attained. The different methods of heating are worthy the attention of the general manufacturer, because, although he may not often require to use them, conditions requiring special treatment in vulcanising frequently crop up. Some of these methods are applicable for heating any particular part of an article, when over-curing would result from re-heating the whole. Jointing telegraph-wire, long lengths of hose-pipes, etc., requires contrivances not found in every factory, and which are useful in other ways, and for other purposes.

(1—*a*) The water-heater is simply a short boiler set on end in the ground, and is usually employed for curing sheet packing. It is most important that the articles should be well bound up, and immersed completely in the water. The heat is run with a thermometer dipping into the water, and the steam is injected into the centre of the heater. The degree and duration of the heating are the same as in steam-curing. The principal advantage of these heaters is that longer lengths of packing can be cured at one time, than would be possible with the steam-heater, without giving extra length, which, in many cases, would scarcely be convenient. To this must be added the fact that blistering is not so frequent if the sheets are well rolled upon the drum, and probably this capability of binding and wrapping, which would not be possible if the sheets were laid out flat, unless at great trouble and expense, gives an extra safeguard against damage by blisters. The packing is run taut upon a drum, with canvas, to prevent sticking, and is well wetted at the same time. When cured, it is, whilst hot, laid out flat on a smooth table to cool. The allowance for shrinking and thickening by contraction is more easily made, and can be more depended upon, than when running in steam. The fabric used for binding is strong canvas.

(1—*b*) The ordinary steam-heater is similar to a steam-boiler; its opening is fitted with a strong iron cover, secured by bolts and nuts. The goods are packed in French chalk, on an iron carriage, running on a set of small rails. The carriage is drawn out by a rope and windlass. Steam-heaters for curing telegraph-wire have been made to open at each end, the object being to pack the carriage at one end, whilst the heat is being run with core packed on a similar carriage at the other end; when one is drawn out, the other is ready to go in. Steam-heaters should be well covered with felt, brickwork, etc., to avoid loss of heat, draughts from open doors, etc. In curing goods by steam, much care must be exercised, as fabrics cannot be heated without having their strength more or less impaired. The compounds used should readily vulcanise at the lowest temperature, and the thickness of the goods should not be such as to retard the heating, and lead to some parts being over-vulcanised, and others only slightly cured. The only way to avoid this is to heat very gently for some time, so as to make sure of an equal distribution of heat, and to use pigments which will assist the vulcanising, either chemically or mechanically, e.g. the better conductors of heat. There are several special kinds of steam-heater in use for curing belting, valves, hose, tubing, joints in telegraph-wire, and coated fabrics. Double or jacketed heaters are used where condensed steam would spoil the goods; and the extra precaution may be taken of wrapping the latter in waterproof cloths.

(1—*c*) The hot-air heater is made so as to revolve, or, if stationary, the goods themselves are turned on a drum. A series of gas-jets, burning in a close cupboard or chamber, makes a convenient heater; the only precaution needed is to place over the jets a sheet of metal, to avoid the direct scorching heat of the burners. A spindle, passing through the ends, carries a drum, on which the articles are packed; by means of a handle, continuous or intermittent motion is given.

A special form of heater is made for dentists who cure their own forms for gums, etc.; the heat is obtained either directly from a gas-burner, as in a stove, or through the medium of steam, generated from a small boiler attached to the stove.

(1—*d*) The goods are imbedded in sand, French chalk, etc., in a bath which is heated by gas.

(1—*e*) The goods are immersed in glycerine, covered up, and placed in a steam-heater, or direct heat may be applied by a sand-bath. Solutions of the alkaline and earthy polysulphides have recently been introduced for curing. Under heat, they yield part of their sulphur to the rubber.

(1—*f*) In curing with the sulphur-bath, the article to be vulcanised abstracts the requisite amount of sulphur; the same takes place, though not so well, with heated tar and sulphur, or beeswax and sulphur. In these methods of curing, the heat is applied much higher at the start than with steam—generally 127°–149° C. (260°–300° F.), consequently much less time is required. If the articles are bound up, the material should be capable of allowing the sulphur to pass through; they should also be kept gently moved during the whole time. Immersion in water immediately after the sulphur-bath, renders the adhering sulphur less troublesome to remove. Articles made from masticated rubber are more generally cured in this way, and are more durable than if ground with sulphur in the mixing-machines. A mixture of beeswax, sulphur, and rosin, is largely used for curing joints in telegraph-wire. The mixture is heated to about 138° C. (280° F.), when the joint, well bound with tape, is immersed in it; the heat is raised to 149°–160°C. (300°–320° F.), in about 20 minutes, and the joint is kept at the same temperature for 1–2 hours. It is essential that sulphur be in excess in this mixture, otherwise it will be partially abstracted from the article to be vulcanised.

(1—*g*) The press shown in Fig. 246 is now extensively adopted for curing large valves, belting, etc. It consists of two parts: the bottom A is stationary, whilst the upper B is movable; the whole is connected with a strong framework F, which supports the gearing for raising or lowering B. In the belt-press, A and B are quite flat; for valves, A is cast with a rim or edge, so that B fits closely into it. The surfaces of A and B must be quite smooth. The article to be cured is laid perfectly flat on the bed-plate A, and B is carefully lowered down upon it; the two parts are firmly clamped together by the screws and nuts S; steam is admitted into A and B, so that the article is in reality cured by means of the heated metallic surfaces of the two steam-chambers. Loss of heat is avoided by coating the chambers with felt. The lower plate of the belt-press may be grooved to the width and depth of belt; but more conveniently, shifting-plates are used, grooved to fit the belt, and having a flat iron bar, of exactly the same width, placed on them. The upper plate is lowered, steam is admitted as before until the portion in the press is cured; this is then drawn through, so as to admit of another section being cured, and so on. Belts thus cured have good square edges, and the pressure used causes the layers or plies to adhere more firmly together. Blowing or blistering, from dampness in the cotton, etc., is avoided by puncturing the uncured belt at a little distance from the press; the punctures disappear in the press. About 20 minutes is required for curing each length of belting. Red-lead and similar pigments which assist the curing are used in the compounds. Besides curing rapidly, it is equally essential to cure with as low heats as possible, so as not to weaken the fabrics forming the plies of the belt.

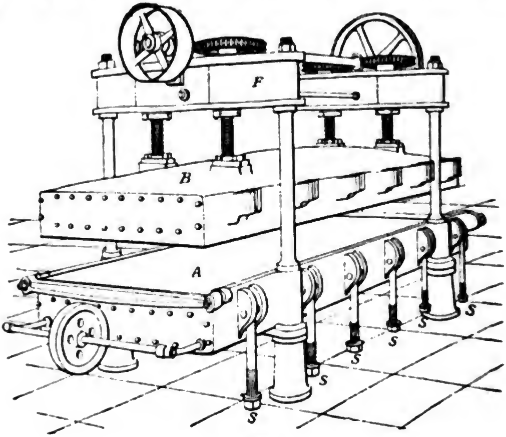

FIG. 246.

A press or heater for curing joints in telegraph-wire consists of a small upright boiler for generating steam. A jacketed tube longitudinally divided, A B (Fig. 247), is attached to the boiler in such a way that the parts can be brought together, and enclose in their annular space, the joint to be cured or vulcanised. After clamping the whole together, steam is admitted into the concentric spaces through I, the condensed steam being led away by attaching rubber tubes at O.

Many small articles are cured in metallic moulds, under pressure in the press, or in open steam. For many kinds of goods, it is important that the metals forming the moulds should not be readily acted on by sulphur during the heating, as a portion of the sulphur would be abstracted, and leave a stain of the metallic sulphide on the goods; consequently, sheets of packing, if cured in the press are prevented from coming into contact with the metal, by sheets of cloth or paper. Tin is the most convenient metal for resisting the action of sulphur; zinc sulphide, being white, indicates the suitability of zinc for coating moulds, etc. All new zinc surfaces should be well cleaned before use; a good plan is to dust them over with sulphur and French chalk, and heat them in the steam cure several times, or they give rise to very troublesome blistering. Boiling with caustic soda helps to prevent this, but is not certain in its action. Brass moulds should be well tinned. Ebonite, or hard-cured rubber, forms very convenient moulds, well adapted where metallic surfaces would be objectionable, from staining, etc. Stains from tin moulds or tinned surfaces are removed by leaving the cured articles in hydrochloric acid for some hours.

(2) Canvas hose is sometimes cured by passing steam through it; the strength of the fibres is less affected, and the liability to loosen the coating by dampness through the fabric is entirely avoided, as the steam comes into contact with the rubber surfaces only.

In water and steam heating, the temperatures are now indicated by thermometers, pressure-gauges being found unreliable. It is usual to reach the maximum gradually, so as to allow the articles to get thoroughly warm and softened, without the vulcanising action setting in. When the heater is closed up, ½ hour, or even much longer for thick masses of rubber, is usually required for reaching the first 66°–93° C. (150°–200° F.), which should be kept up for 30 minutes or so; during the next 30 minutes, the temperature may be allowed to rise to 115°–121° C. (240°–250° F.), which is maintained for 1–2 hours; the temperature is again gradually raised to 138°–144° C. (280°–290° F.) and kept constant for 1–2 hours. Very thick masses of rubber may require several hours for curing. Heats too rapidly changed cause blisters or sponginess, followed with bursting of the mass, even if enclosed in strong iron moulds. Vulcanite or ebonite is finished off at 149° C. (300° F.).

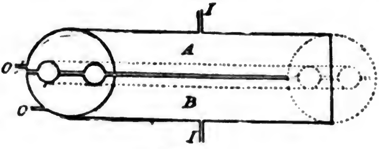

FIG. 247.

(3) Parkes' process of vulcanising with chloride of sulphur is extensively used for surface curing, such as single textures for garments, and sundry small articles, manufactured from masticated sheet rubber, as tobacco-pouches, tubing, rings, etc. The chloride is mixed with 30–40 times its bulk of carbon bisulphide for ordinary fabrics; but for solid rubber goods, much more dilute solutions must be used, and a longer immersion allowed, than with stronger solutions, since the surfaces would be overcured, and crack. Chloride of sulphur in vapour is preferable in many cases to the mixture in carbon bisulphide. The articles are then suspended in a lead-lined chamber, well varnished with shellac, and heated by steam-pipes; the chloride is gently evaporated, either by placing it in an open dish on the steam-pipes, or by using a small retort, the end of the

tubulure of which passes into the chamber. The chloride is evaporated by a small gas-burner. Chlorine, bromine, hypochlorous acid, and several other vapours, can be used in the same way. Although Parkes uses these vapours with solvents of rubber, they act equally well, and in many cases more certainly, without them.

Several improvements for curing double textures have been recently introduced, the most important of which is the Silvertown process. This consists in passing the rubber surface of each piece to be united over a roller, revolving in a mixture of chloride of sulphur and bisulphide of carbon; the acid mixture does not come into contact with the fabrics, so that no injury can happen either to the colour or the fibres, and the most delicate tissues can be treated. Another process, patented by Anderson and Abbott, effects the curing by suspending the fabrics or completed garments in a chamber, which is afterwards charged with the vapours of chloride of sulphur, it is questionable how far this method can be depended upon, without injury to the fabrics. If the colours are discharged by the chloride of sulphur, they are brought back by placing a dish of liquid-ammonia in the drying-room.

Single textures are cured by passing the coated surface over a roller, revolving in the curing-mixture, as above. The fabrics are run on to a large drum, and the cured surface, which is still sticky, is kept from coming into contact with the cloth surface, by making the drum pick up a roller whenever its arms pass the frame which supports them, so that between each two layers of material, there is a space of about 2 in.; as soon as the bisulphide has nearly all evaporated, the fabrics are run on to a roller for hanging up.

India-rubber, Paints or Varnishes.—India-rubber paints or varnishes can be made by mixing pigments with a little thin solution in some easily volatile solvent; after the solvent has evaporated, the film of rubber can be cured by the application of a little of the cold-curing liquid. The pigments easily retain their colours when applied in this way; but if mixed up with oil, they are not so elastic after a little exposure, and become harsh, and crack.

Varnishing India-rubber Textures.—Single textures, when cured, are well wiped over, and varnished with shellac dissolved with liquid ammonia in water. Lampblack is added for black goods; bleached shellac or seedlac is best suited for white or light-coloured goods. The varnishing is performed by passing the fabrics over a roller running in a trough of varnish, or better still, by letting the varnish fall on the rubber surface. It spreads of itself, the excess being removed by passing under a close-fitting scraper or pad. It is dried by running over a large drum or cylinder, heated by steam. Small articles are varnished by a soft sponge.

Joining India-rubber Textures.—Cured or uncured fabrics are joined for garment-making and other articles by cementing together with thin solution. Camphene was largely used a few years ago for softening the edges of rubber for uniting. It leaves the rubber more sticky than any other solvent does. Its present price precludes its use on a large scale. Several coatings are applied, each being allowed to get nearly dry before the next is rubbed on; the two adhesive surfaces are then well rolled down by manual labour, and the excess of cement which oozes out is rubbed off, when nearly dry, by a piece of masticated block rubber. Double textures are stripped so as to cement the rubber surfaces, by applying first a little solvent, which renders the stripping-off easier. In spreading, it is necessary to coat one of the fabrics with less pressure, so as not to drive the rubber into the meshes of the cloth. Such coatings are specially designated "stripping-coats." Without such arrangement, double textures could not be made with watertight seams.

Testing Cured Goods.—Well

cured rubber should swell but slightly in coal-tar naphtha, and leave no imprint of the finger-nail when pressed into it. On stretching, it should draw out evenly; sudden or gradual extension should produce but little, if any, permanent elongation. Defects in curing are air-cavities and blisters due to insufficient sulphur, heat, or moisture, when the articles may be spongy and soft, though tolerably well cured. Over-curing imparts a harshness to the surface. Under-cured rubber is clammy, more or less adhesive when the freshly cut edges are pressed together, swells readily in naphtha, and retains a considerable elongation on stretching. Buffers, springs, etc., are tried in a screw-press for two or three days. Diving-dresses, fishing-boots, powder-bags, etc., are filled with water, and allowed to stand for several hours. Steam is used for those articles made of solid rubber; any defect is rendered visible in a few minutes by damp spots appearing on the surface. Fire-hose and other strong tubes are tested by forcing water in until the required pressure is shown on a gauge. Defective proofing is shown by taking a piece of the fabric, with the rubber surface upwards if a single texture, and placing it over a sieve or deep hoop, so as to hold water; after some hours, water will have leaked through to the under side, if the proofing is imperfect. A test used by the Admiralty for vulcanised rubber and sheeting is as follows. The sample is placed in a hot-air oven B (Fig. 248); through the cover C passes a thermometer T, reaching down to within a very short distance of the surface of the sample, which should rest on a flat clay-tile, reaching about half-way up, as shown by the dotted line. The temperature is first raised to 132° C. (270° F.), the sample is placed in the oven, and the dampers are carefully adjusted, so that this temperature can be kept constant for one hour. A Bunsen's burner is a convenient method of heating. No stickiness should be perceptible with a perfectly cured sample, when, after heating, it has cooled down to the temperature of the air.

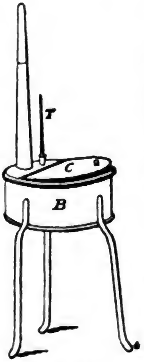

FIG. 248.

As petroleum acts energetically on vulcanised rubber, steam-valves for marine and other engines have become specialities with the leading india-rubber manufacturers. The distention produced by these mineral oils at 100° C. (212° F.) affords a ready test for the suitability of a compound for steam-valves; a good valve should remain firm, and swell slightly after several hours.

Efflorescent sulphur is removed from the surface of vulcanised goods by boiling for some time in a strong aqueous solution of caustic soda. Fabrics are washed over with the same solution, and well dried. Carbon bisulphide can be used for this same purpose. The boiling process is called "devulcanising," but more correctly is desulphurising. Deodorising is effected by exposing the goods to air and charcoal; bleaching is rapidly performed by exposure to sunlight in the open air.

Pigments. — A manufacturer should know whether his pigments are what they are represented to be. The following simple tests will answer generally for the more important:—

Sublimed or flowers of sulphur, stirred into distilled water, should only slightly redden litmus-paper, as sulphurous acid modifies the action in curing. It should entirely disappear when heated, and should readily yield about 60–70 per cent. of its weight to bisulphide of carbon. Ground sulphur has been lately introduced as a substitute for the above. It agrees with it, except in that it entirely dissolves in a little bisulphide of carbon. It should be a more acceptable agent for curing than the preceding. Milk of sulphur should entirely dissolve in bisulphide of carbon, and disappear when heated in a porcelain dish.

Sulphide of antimony is readily soluble in sulphide of ammonium. A solution of tartaric acid should take up only a small proportion of soluble salts or oxides, which are precipitable by sulphuretted hydrogen from this solution for estimation. Bisulphide of carbon should remove 25–40 per cent. of sulphur, and leave a perfectly bright red residue.

Oxide of zinc, shaken up in a test-tube with sulphide of ammonium, should be only slightly darkened by traces of lead and iron. A slight insoluble residue (silica, sulphate of lead, etc.) should remain after treatment with dilute sulphuric acid. The filtered solution, neutralised with ammonia, and the same added in excess, and left in a warm room for some time, should show only a slight deposit of hydrated sesquioxide of iron. The filtered solution, strongly acidified with nitric acid, treated with solution of molybdate of ammonia, and allowed to remain in a warm place for 24 hours, should yield only a very slight yellow precipitate, due to arsenic.

White-lead and litharge, if pure, dissolve readily in nitric acid. Commercial litharge yields an insoluble residue (fine sand, etc.) of 17–18 per cent. Insoluble matters in white-lead ought to be insignificant. It is sometimes adulterated with sulphates of lime and baryta. The nitric acid solution, submitted to the action of sulphuretted hydrogen for a long time, and the clear portion evaporated, should show but a very slight residue, principally iron.

Red-lead, digested for a short time with fuming nitric acid, and then largely diluted with water, should dissolve easily. The solution, treated as above, should give little or no residue when the liquid filtered off is evaporated. It is not so largely adulterated as has been stated.

Caustic lime should effervesce but slightly with hydrochloric acid, and should leave a small quantity of undissolved matter (silica and small pieces of flint). Hydrated carbonate of magnesia is entirely soluble in dilute sulphuric acid; lime, if present, should not exceed 1–2 per cent. The loss due to carbonic acid is about 33 per cent., and to water, 30 per cent.

To test for moisture, a weighed quantity of the substance is placed in a desiccator for about 24 hours. The sulphuric acid in the dish absorbs the moisture, and the sample is reweighed. Moisture in pigments is a source of serious trouble, consequently everything should be well dried, and kept free from damp. As sulphur oxidises on exposure to the air, especially in a warm place, it should be kept well covered up when sifted.

The pigments which are incorporated with rubber and sulphur have different effects, as they may retard or assist the vulcanising. Red-lead and white-lead assist the curing, probably by forming sulphurous acid when heated with the sulphur, or by giving up their oxygen to the rubber. They are converted into sulphides by curing. Caustic lime and magnesia (hydrates) have an accelerating influence, when used in small quantities; in larger quantities, lime will yield hard compounds at much lower temperatures, and in shorter time for curing, than if sulphur alone had been used; these substances are probably converted into sulphides, for when a piece of this rubber is broken, and slightly moistened with an acid, distinct traces of sulphuretted hydrogen are perceptible. Carbonates of lime (whiting) and magnesia (hydrated carbonate) do not behave in this way. Magnesia hardens the rubber, by its absorptive properties; and the same may be said of French chalk, baryta, and similar pigments. Oxide of zinc retards the curing; it is not certain whether it is converted into sulphide, although rubbers containing much oxide of zinc require more sulphur. If the oxygen were liberated in the same way as with lead oxides, or caustic lime, a similar result might be expected; this not being the case, it is possible that if a sulphur acid be formed, it is taken up by the zinc.

Moulding, etc.—Few shaped articles can be cured with certainty without some support. Compounds which are sufficiently firm to retain their shape tolerably well, when heated, are simply imbedded in French chalk; most articles, however, are cured in moulds, either of iron or of brass, having the exact size and form of the required article. For solid goods, the rubber is forced into the moulds under pressure, which is kept up until they are cured. Hollow goods are placed in the moulds in segments, which are joined together, and before being closed up, a little water or carbonate of ammonia is introduced; the article is then placed in its proper mould, clamped, etc., ready for curing. The water or ammonia expands during the heating, and causes the rubber to completely fill up the mould. Buffers, springs, and washers, are moulded in long cylindrical iron moulds, accurately turned inside; a spindle passing through the centre forms the required hole, and serves to clamp the ends of the moulds tightly together; when cured, the springs are removed from the moulds, and cut up in a lathe into washers, or any desired thickness of buffers. An unsoiled thin calendered sheet is sometimes rolled up on a spindle or mandril, taking care to exclude all air from the folds, and rolling evenly on a hard surface; a binding of cloth is applied as tightly as possible, which serves as a mould in curing. Small washers or rings are cut from these in the same way as buffers, a wooden mandril or spindle being passed through the central hole formed by the wire or rod on which the sheet has been rolled. Small articles are conveniently formed by repeatedly dipping moulds or forms into a solution of india-rubber, and drying after each immersion, until the required thickness has been given to the article.

Mats are formed by perforating the calendered sheet by punches, so as to give the required device; the design is first stencilled in chalk or whiting on the sheet, the parts are removed so as to leave the design or pattern, when it is cured in French chalk.

Compressed paper-pulp, plaster of Paris, and vulcanised rubber itself are frequently employed for moulds in curing. Vulcanite sheets are cured between sheets of pure tin-foil, smeared over with lard-oil, or, to avoid soiling with metal, sometimes between sheets of hard cured rubber.

The plies of belting, hose, hemp or rope packing, etc., are put together by manual labour; each ply is well rolled down by pressure. Corrugated rollers are sometimes used to give rough surfaces to washed or calendered sheets of rubber. Rubber compounds are frequently calendered on fabrics which are cured with the goods, and stripped off afterwards. This stripping is facilitated by well damping the cloth with water; if this is ineffectual, a little naphtha should be applied after thoroughly drying off the water. In such cases, the fabric itself forms the mould by keeping the article in shape. Telegraph-wire is kept cylindrical by a lapping of felt or other fabric.

A very convenient metal or alloy for moulds or shapes is a mixture of tin and lead, which can be recast with trifling loss for any altered design. The stain left by iron moulds can be removed by dilute sulphuric acid.

Dipping forms or moulds into solutions of rubber, and allowing the solvent to evaporate, is a very convenient way of obtaining many small articles, which are required to be seamless and smooth; the mould is removed either before or after the article is vulcanised.

Vulcanite is stamped into various forms or devices by cutting-dies; the hard cured material is made warm before being placed in the press; the dies are made of well-tempered steel. Combs and similar articles are stamped out by cutting-dies in the same way. Tubing or sheet can be readily bent to any required form, when heated over a gas-jet, until it becomes soft. In a lathe, vulcanite admits of being turned or worked like wood or metal. It is polished by means of a cloth buff, running at about 800 revolutions a minute, with brick-dust and oil. Vulcanite is used for insulators for aërial lines of telegraph, cells for galvanic batteries, photographic baths, etc. Battery cells and insulators are tested electrically by being filled with water, slightly acidulated with sulphuric acid. Vulcanite has almost entirely replaced glass for frictional electric machines. With the ordinary silk rubber, it yields negative electricity.

The principal articles made from soft rubber are valves, springs, buffers, washers, tubing, packing, and telegraph-wire; spread on cloth, it is largely used for pontoons, garments, balloons, diving-dresses, sheeting, garden-hose, canvas packing, belting, invalid mattresses, etc. From hard rubber or ebonite, acid-pumps, battery cells, insulators, tubing, rod, sheet, photographic, surgical and sundry vessels for holding chemical liquids. Kamptulicon is manufactured by incorporating cork-dust with waste rubber (*see* FLOORCLOTH).

Reworking Rubber Compounds.—For some years past, india-rubber manufacturers have endeavoured to utilise the parings of vulcanised rubber, old valves, packing, etc. So inferior is the product that it is only suitable for very low-class goods; hence it is that old vulcanised rubber realises such a small price compared with the new article. Numerous patents have been devoted to the object, such as grinding with water, naphtha, caustic alkalies, acids, etc. Generally the rubber is ground dry between a strong pair of grinding-rolls. Ground waste being liable to spontaneous combustion, it should be carefully watched, and kept in a cool place. A short time ago, it was much used for stuffing chairs, etc. Numerous cheap articles are now made from ground waste, by agglutinating with dough or solution, compressing, and curing. Compounds containing ground waste cure more readily than fresh rubber. In purchasing rubber for reworking, it is difficult to give any very definite tests as to its value. Most manufacturers mark their goods, which is of great use in selecting old valves, buffers, etc. Hose-cuttings and belting, before being cured, are ground up together, and are very useful for packing, to withstand attrition or other rough treatment. As woollen cuttings cause blisters and sponginess, care must be taken to separate them from cotton cuttings, by sorting, or by boiling in caustic alkalies when the fabrics are mixtures of wool and cotton, or silk and cotton. Forster and Heartfield proposed the use of wool for india-rubber sponge. By heating, the wool is easily charred, and the moisture or gases generated give the rubber a honeycombed structure.

When vulcanised rubber is strongly heated in a closed vessel under pressure for some hours, and the liquids produced by its decomposition are distilled off by superheated steam, or removed by compression, a soft mass is obtained suitable for incorporating with fresh rubber. Vulcanite waste is reworked by being finely ground, when it can be incorporated with fresh uncured material. When thoroughly cured, it cannot be jointed nor repaired; but if slightly cured, adhesion between it and new material can be successfully secured. Hence large masses should never be cured thoroughly in the first heating.

Rubber Substitutes.—(*a*) Under the name of "artificial rubber," several compounds have been introduced with more or less success. The basis of the most important are oxidised and vulcanised oils (*see* FLOORCLOTH AND OILCLOTH). Lake's "improved artificial india-rubber compound" consists of saponified resin and vulcanised oils, which are incorporated with india-rubber or gutta-percha, and vulcanised in the usual way. In Day's "improved substitute for india-rubber," the oils are partially saponified by acids, and are then heated with sulphur, etc. These acid compounds cannot be used in the manufacture of fabrics, as the heating would destroy the fibre. Bruce Warren's "thinoline" or vulcanised oil consists of linseed-oil, or other drying oils, vulcanised by adding sulphur at high temperatures. Oils vulcanised by chloride of sulphur are obtained by treating similar oils with chlorinated sulphur, or sulphur chlorides; the principal objection to these compounds is their acid qualities, which prevent their being used with fabrics, or certain pigments. Leather parings and wool have been proposed as substitutes, when previously treated with chloride of sulphur, or heated in molten sulphur. Oxidised oils have also been proposed, but have not been so successfully employed. A material called "vulcanised fibre" has lately been introduced. It consists of animal or vegetable fibre, paper-pulp, etc., mixed with vulcanised oil and glycerine, and calendered or spread by a machine.

(*b*) A substance very like rubber can be made of linseed-oil or fish-oil and sulphur. About an ounce of sulphur to a pint of oil.

Tubing.—The paste used in making tubes may be composed of 59 parts of caoutchouc, 35 of oxide of zinc, 5 of sulphur, and 1 of pulverulent lime. The strips of caoutchouc are first sprinkled with powdered talc to prevent their sticking; to render them more homogeneous, they are usually placed for an hour upon a hollow table heated by steam up to 250° F. A strip is folded double, to a breadth proportionate to the diameter of the tube, and the edges cut with shears. The incision through the two thicknesses is made at an angle of 45° with the surface of one side, and consequently of 135° with the other, Fig. 249. When the cylindrical form is given to the piece by means of an iron rod, the two surfaces of the section fit each other, as shown in Fig. 250, and a pressure with a bar, or a few blows with a flat rule, is all that is required to make the edges adhere firmly.

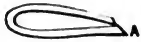

FIG. 249.

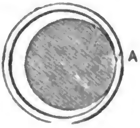

FIG. 250.

The tubes are in this way made upon smooth iron rods from 5 to 15 mm. in diameter and from 10 to 13 metres in length, and sprinkled with talc. When the joint is effected, the tubes are wrapped in a cloth and vulcanised by heating them for an hour and a half or two hours to a temperature of 270° to 285° F., four hundredths of sulphur having been introduced into the paste at temperatures varying from 105° to 212° F. For this purpose the tubes with their rods are placed in a vertical cylinder from 12 to 13½ metres in height and hermetically closed. Steam is then introduced, and the temperature kept at 273° F. by means of a gauge indicating a pressure of three atmospheres. When the tubes have cooled, the rods are withdrawn. Should the tube stick to the rod, the adhesion is destroyed by injecting water between them with a small hand-pump.

Solvents for Rubber—(*a*) These are ether (free from alcohol), chloroform, bisulphide of carbon, coal naphtha, and rectified oil of turpentine. By long boiling in water, rubber softens, swells, and becomes more soluble in its peculiar menstrua; but when exposed to the air, it speedily resumes its pristine consistence and volume. Oil of turpentine dissolves caoutchouc only when the oil is very pure and with the application of heat; the ordinary oil of turpentine of commerce causes india-rubber to swell rather than to become dissolved. In order to prevent the viscosity of the india-rubber when evaporated from its solution, one part of caoutchouc is worked up with two parts of turpentine into a thin paste, to which is added ½ part of a hot concentrated solution of sulphuret of potassium in water; the yellow liquid formed leaves the caoutchouc perfectly elastic and without any viscosity. The solutions of caoutchouc in coal-tar naphtha and benzoline are most suited to unite pieces of caoutchouc, but the odour of the solvents is perceptible for a long time. Bisulphide of carbon is the best solvent for caoutchouc. This solution, owing to the volatility of the menstruum, soon dries, leaving the latter in its natural state. When alcohol is mixed with bisulphide of carbon, the latter does not any longer dissolve the caoutchouc, but simply softens it and renders it capable of being more readily vulcanised. Alcohol also precipitates solutions of caoutchouc. When caoutchouc is treated with hot naphtha distilled from native petroleum or coal-tar, it swells to 30 times its former bulk; and if then triturated with a pestle and pressed through a sieve, it affords a homogeneous varnish, the same that is used in preparing the patent waterproof cloth of Macintosh. Caoutchouc dissolves in the fixed oils, such as linseed-oil, but the varnish has not the property of becoming concrete on exposure to the air. Caoutchouc melts at a heat of about 256° or 260° F. after it has been melted; it does not solidify on cooling, but forms a sticky mass which does not become solid even when exposed to the air for months. Owing to this property, it furnishes a valuable material for the luting of stop-cocks and joints intended to remain air-tight and yet be movable.

(*b*) The solvents of india-rubber have already been alluded to. Those chiefly used are "solvent" naphtha (sp. gr. 0·850 at 60° F., boiling at 240°–250° F., and leaving no more than 10 per cent. residue at 320° F.), shale spirit, and benzol. Mixed with purified solid paraffin, by grinding together, rubber will acquire the property of melting by heat, and setting solid again when cooled. Solubility is promoted by grinding or working. Raw or washed rubber is less soluble than that masticated or ground, and well-ground rubber is more easily taken up than that which has been less worked. All descriptions of raw rubber, in the same stages of manufacture, do not exhibit the same degree of solubility; the better qualities are less soluble than the inferior. Generally, washed rubber is used for dissolving for waterproofing. There is no doubt that in the case of Parà rubber, and some of the other cleaner kinds, the process of washing could be dispensed with, provided the raw article could be freed from adhering dirt, crushed between grinders, and afterwards hung up in a dry and warm room to season. The mixture of india-rubber and solvent is technically known as "solution" when thin, and as "cement" when thick.

When pigments are to be incorporated with the solution, the easiest plan, in most cases, is to grind the rubber and pigments together, run out into a thin sheet, and digest in naphtha, with a slight stirring as it is added. The finishing is performed by dough-mixers or rollers, after which, for the better class of goods, the softened mass is forced through wire gauze, by means of a powerful screw-press. Coloured solutions are sometimes used as paints: the dry pigments are mixed in with the rubber in a volatile solvent. The stiff solution of rubber used for spreading is technically called "dough." In handling this, the workman uses a little soap, so as to prevent it sticking to his fingers.

Punching Hard Rubber.—I recently discovered something which was entirely new to me, and may be to others. Some time ago I was in the electrical business, and among other things had several different kinds of hard rubber insulators to get out. On account of the well-known tendency of this material to curl up when heated sufficiently to be handled in the press without danger of cracking, I did not dare to do much in the way of piercing and blanking dies. One piece in particular was a very awkward and, consequently, rather expensive one to make by hand, and was required in quantities large enough to warrant trying desperate remedies.

I thought the matter over, and decided to try the effect of heating the punchings and cooling them between flattening-dies in a foot-press. I had a die made, piercing and blanking the piece. The punchings, I must say, did not look very encouraging—they were of nearly every possible shape, except flat. I rigged up a gas-stove and a pan of water by the foot-press and threw in a handful of stampings, set up the flattening-dies, and got ready for operation. Imagine my surprise when I picked a few stampings out of the hot water and found them perfectly flat without ever seeing the flattening-dies. I do not mean approximately flat, but as nearly flat as the sheet of rubber they were punched from, with no rings around the pierced holes, nor anything that would even show from which side they were punched. Since then we have had no trouble in making even difficult stampings from hard rubber, the "hot-water bath" leaving nothing to be desired.

This may be an old trick to some, but I believe the majority of readers are not acquainted with this simple and effective treatment. ('American Machinist.')

To make Articles of Rubber Odourless.—Cover both sides of the article with a thin layer of animal charcoal, and heat it together with the animal charcoal to from 122° to 140° F. for 3 to 4 hours.

Rubber Toys.—In making ordinary hollow rubber balls, the sheet of prepared rubber is cut into pieces with rounded sides and two points (double convex), three pieces usually going to a ball. The edges are wetted with rubber solution (rubber dissolved in naphtha) and the joints pressed firmly together. When this is done, there is little resemblance to a ball, the article being more like a large Brazil-nut. Just before closing the last opening, a small quantity of carbonate of ammonia is put inside, this substance giving off a vapour when heated, the vapour having sufficient force (in confinement) to force out the walls of the ball to a round or any other shape desired. After this substance is inserted, the opening is closed making the intended ball air-tight. The rubber article is now put into an iron mould of the size and shape of ball required, and the moulds are packed in frames to go into a vulcaniser. Iron rods are used to keep the moulds in place and closed in the frames. Care must be used in this, as when the heat is felt, considerable force is exerted in the moulds and quite a heavy and well-made frame is required to resist this. If a mould gets out of place, there will be some risk, and the work of the whole frame will be spoiled. On afterwards coming out of the mould, each ball will be found of perfect shape with no visible marks of joints, except a slight ridge due to the joint in the mould itself. This ridge is ground off with a stone used for this work. Rubber animals and dolls (hollow) are made in the same way except that the cut pieces of sheet are of different suitable shapes, and the moulds differ accordingly. Some makers instead of carbonate of ammonia use ammonia water or even plain water, the heat of the vulcaniser being sufficient to convert water to steam. The moulds, too, can be of plaster of Paris, if only one or two specimens are required.

The rubber sheet used for toys is seldom, if ever, pure rubber. "Fillers" are used in the manufacture, these being a powdered adulterant, such as zinc sulphate, calcium sulphate, chalk, clay, talc, magnesia, silica and barium sulphate. Sulphur is invariably added for the vulcanising effect.

The painting of rubber toys is done with spirit varnish in which suitable colours have been mixed. Oil paint must not be used, as oil has a destructive action. This painting is, of course, purely decorative and external. If a coloured rubber is required, the pigment is added in the manufacture of the sheet material.

* * *

INDUCTION COILS.

AN electrified wire is capable of exciting a current in another wire placed near it, but not in contact, and such a current is termed an induced current. Induced currents generally have a very high electromotive force, and are capable of sparking across far greater spaces than can be accomplished by ordinary battery currents. An induction coil consists of a cylindrical bobbin with an iron core, surrounded first by a primary coil of stout wire, and then by a secondary coil of very fine wire, carefully insulated between the different parts. The primary coil is joined to the terminals of some Bunsen or Grove cells, and includes an interruptor (contact breaker) and a commutator. The object of the former is to repeatedly and rapidly make and break the primary circuit. The primary coil, destined to carry strong currents, and produce a powerful magnetic field at the centre, is made in a few turns, so as to lessen resistance and avoid self-induction of the primary current. The iron core, whose value depends upon its great co-efficient of magnetic induction, is best made of a bundle of fine wires to avoid induction currents. The secondary coil is made in many turns that the co-efficient of mutual induction may be large, its increased resistance being immaterial in the presence of such great electro-motive force. With these general explanations, the construction of induction coils may be entered upon, the information being mainly condensed from Dyer's practical little book.

Primary Coil. — Prepare a paper tube about 4 in. long and ¾ in. diameter, and wind on it 2 or 3 layers of copper wire covered with cotton, and of the size of ordinary bell wire. A binding screw is attached to each end of the wire, as shown in Fig. 251, by which means it can be united to a battery. The paper tube upon which the wire is wound is filled up with a bundle of iron wire *a*.

Secondary Coil.—Prepare a second paper tube of similar length to that in the centre of the primary coil, but large enough in diameter to slide over it. Fit 2 discs of wood on the ends of this tube, and then wind on 5 or 6 layers of cotton-covered copper wire about the size of stout packthread, and attach binding screws to its beginning and end (Fig. 252). If the primary coil be attached to a battery, and contact be broken rapidly, distinct shocks may be felt from the induction coil. Thus are constructed the coils of electro-magnetic machines for medical and experimental purposes. But such are not intensity coils, for their mode of construction involves the loss of nearly all the electrical current excited in the wires of which they are composed.

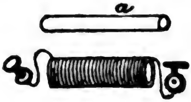

FIG. 251.

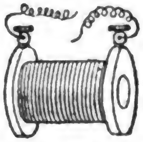

FIG. 252.

Intensity Coils.—The parts of an intensity coil are: reel, primary coil, secondary coil, iron bundle or core, contact-breaker, condenser, pedestal or base, and commutator. The dimensions given may be considerably varied without impairing the efficiency of the apparatus.

Reel.—The reel consists of a hollow cylinder or tube, with a square or circular plate firmly fixed on each end. The cylinder is formed of paper, and the plates or reel-ends of gutta-percha or ebonite. The reel-ends are flat, and not less than ⅜ in. thick; if circular, a facet is made on the edge of each, so that when the reel is complete it may stand steadily on the pedestal. The hole through the centre of the reel-ends is turned perfectly true, so as to fit the outside of the cylinder; and a shoulder is left on the outer face sufficient to prevent the paper cylinder from being pushed through the ends when being fastened on. The reel-ends may be 4½ in. in diameter if circular, or 4 in. by 4 in. if square. They can be glued to the paper cylinder. The cylinder is formed of cartridge-paper cut into a long strip, and when gummed or pasted on one side, wound round a rod ⅞ in. diameter. When properly done, a firm tube, 7 in. long, 1 in. diameter, and about 1/16 in. thick, is obtained. This is allowed to dry thoroughly, and the ends are cut at right angles to the axis. The ends are firmly fastened to the cylinder; in order to effect this, the holes through the discs are slightly tapered, the larger dimensions being towards the shoulder. Before fixing the paper cylinder, a slightly conical plug is provided, fitting the inside of the cylinder. When the parts are ready and carefully coated with the glue, they are put together, and the conical plug is gradually pressed into the end of the cylinder, which will expand it a little, and force it into close contact with the sides of the hole in the disc; it remains in this position until the glue is thoroughly set, when the plug can be removed. The reel is provided with a hollow groove in the edges of the discs, if circular, to receive the pieces of catgut cord that are to fasten it to the base; if square, they can be fastened by screws; 2 holes are drilled through one end of the reel, to allow the primary wire to be passed through; these should be about ⅛ in. diameter, and somewhat oblique in direction, so that the wire, where passed through the reel-end, may not be at right angles with the axis of the reel.

Primary Coil.—The primary coil consists of No. 16 cotton-covered copper wire, averaging about 18 yd. to the lb. One end of the wire is passed from the inside through one hole in the reel-end, so as to project 6 or 8 in., and the wire is then carefully wound over the cylinder up to the other end, and back again, so as to form 2 layers, one over the other. When completed, the remaining end of the wire is passed through the second hole in the reel-end. Before putting on the wire, fit a wooden or metallic rod inside the paper cylinder of the reel, or the cylinder is likely to be damaged by the force required to wind the wire round it. When the primary wire is on, it is varnished with 2 or 3 successive coats of shellac dissolved in spirits of wine, care being taken that one coat is thoroughly dry before another is put on. The first coat should be thin, so as to be readily absorbed by the covering of the wire and conveyed to the nether layer. When the varnish is dry and hard, the primary wire is covered with a strip of cartridge-paper passed 2 or 3 times over the wire, and fastened by gum or glue. This paper must be cut exactly to the width between the inside faces of the ends of the reel, and drawn tightly when put on, but not so tightly as to show on its surface the interstices between the rows of wire. This paper covering, when dry, is varnished to present a smooth cylindrical surface, having no space between it and the inside face of the reel-ends. Shellac varnish forms a good insulator, but is not so effective as ordinary black rosin and beeswax. This preparation is rather more difficult to apply, but greatly superior to the varnish when done. The rosin is melted in an earthen vessel, and a small quantity of beeswax is added to it, the proportion to be determined by experiment, the use of the wax being to diminish the friability of the rosin without interfering with its hardness: usually about $\frac{1}{8}$ by weight will be found suitable. The rosin and wax, fully melted and heated almost to boiling, are poured over the wire from a ladle, turning the coil round, and repeating the application until the mixture has completely permeated the strands and filled up all the interstices between the wires. If this be done neatly, the paper covering may not be required. When the rosin mixture is employed as the insulating material, it is convenient to wind the wires on the cylinder, and insulate before the reel-ends are fixed on.

Secondary Coil.—This is formed of No. 38 copper wire, covered with silk, and averaging 180 yd. to the oz.; the quantity required is about 6 oz. In winding on the reel, scrupulous care is needed, to avoid any break in the wire, and any kink or bend in it. The diameter of this wire is 0·0067 in. The layers of the secondary wire should not be carried close up to the end of the primary coil, thus avoiding the possibility of the wire of one layer sinking down to the level of that below it. When a layer of wire is finished and insulated, it is next to impossible to take it off again; consequently every care must be taken to prevent any failure in winding it on. One layer of the secondary wire is wound on at a time, and then coated with the shellac varnish or rosin mixture. When done, the layer is further insulated by wrapping round several thicknesses of gutta-percha tissue, or thin white demy paper soaked in the rosin mixture, and allowed to become hard. Whichever material be used, it is cut in strips a little wider than the length of the layer of wire it is to cover, and wound on tightly but smoothly. The length of the strip should be such as to wrap 3 or 4 times round the coil; it is fastened with the varnish or rosin mixture. When the requisite quantity of wire is put on, 8 or 10 folds of the insulating paper or tissue are wrapped round the coil before the ornamental covering of silk velvet is applied. If the wires forming the coil have been put on before the reel-ends have been fixed to the inner paper cylinder, the reel-ends must now be put in place, and when firmly set, the spaces between the ends of the layers of wire and the inside of the reel-ends are filled up with the rosin mixture so that the insulation may be perfect. The winding of the secondary wire begins at the opposite end of the coil to that at which the winding of the primary coil commenced, and finishes at the end where it began. The 2 ends of the wire are wound into helices, and these can be passed through 2 holes in the reel-ends, in order that they may be connected with the other part of the apparatus.

Before winding the secondary wire, it is tested in the following way: Attach one end of the wire on the bobbin (as it comes from the covers) to one electrode of a battery, and the other end to one of the binding screws of a galvanometer. The circuit is completed by uniting the other electrode of the battery with the other binding screw of the galvanometer, and if there be no break in the wire, a deflection of the needle will ensue. Should no deflection take place, the wire must be unwound from the bobbin, carefully examined, and the break detected and soldered. When the continuity of the wire has been effected, winding it on to the reel can be commenced. Each layer, as wound on, and before insulated, should be tested by the galvanometer. For this operation a different course is adopted. The beginning of the secondary wire on the reel is connected with one of the binding screws of the galvanometer, and the end of the wire that still remains on the bobbin is attached to the other binding screw, as in Fig. 253. The 2 ends of the primary coil are connected with the battery, and if there be no fault, the needle of the galvanometer will be deflected; the layer can then be insulated, and the same course adopted with each layer. To solder 2 ends of the secondary wire together, the silk coating must be removed from each end—the ends brightened by rubbing with fine glass paper, put side by side in contact with each other, a small piece of tinfoil wrapped round both wires, moistened with a solution of zinc chloride, and moved over the flame of a very small spirit-lamp; in a few seconds, the tinfoil melts and unites the wires. Should it be necessary to apply the wires again to the lamp, they are first moistened with a fresh portion of zinc chloride. The wires should overlap each other about ½ in.; when the soldering is complete, the silk covering is carefully replaced.

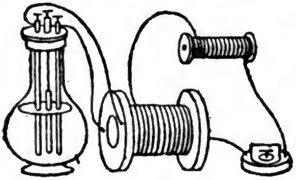

FIG. 253.

Iron Bundle.—This is a bundle of uncovered iron wires, about No. 18 gauge, quite straight, of exactly equal lengths, and about ½ in. longer than the outside measurement of the coil. The centre of the coil is filled with these wires; and then a short piece of larger wire, carrying on one end an iron disc about ¼ in. thick and ⅝ in. diameter, is pushed into the centre of the coil at each end, so as to secure the bundle in place.

Contact-Breaker.—(*a*) The form used for intensity coils is the vibrating contact-breaker. It is not desirable to use a separate electro-magnet for intensity coils, as a resistance is offered by it to the passage of the battery current, therefore the iron bundle in the coil, which becomes an electro-magnet, is used instead. This necessitates an alteration in the position of the spring and iron clapper, which, as shown in Fig. 254, are placed vertically. The spring is fixed to a brass block attached to the pedestal, having a vertical plate rising on one side. A screw passes through this plate and comes into contact with the spring a little way above its point of fixation to the block; the use of this screw is to regulate the tension of the spring and its distance

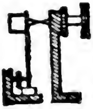

FIG. 254.

from the end of the iron bundle. At the top end of the spring is an iron cylinder or clapper about ½ in. long and of similar diameter; the spring is adjusted so that the face of this cylinder may, when the spring is at rest, be about ¼ in. from the end of the bundle. A strong brass pillar rises up also from the pedestal, and reaches a little above the centre of the coil. Through the top of this pillar a strong screw (the platinum screw) passes, carrying on its end a piece of platinum, which comes into contact with the spring where the iron cylinder is attached to it. The spring at this part is armed with platinum, and it is here that the contact is made and broken. The platinum screw is provided with a running boss so that, when the screw is adjusted, the boss can be brought up tightly against the pillar, and thus prevent the screw from shifting. The surfaces of the platinum require to be smoothed and scraped from time to time, in order to maintain complete contact.

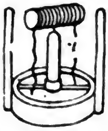

FIG. 255.

(*b*) Fig. 255 represents the apparatus devised by Dr. Ritchie as a mode of obtaining rotary motion by the temporary magnetisation of an iron bar, which is extensively employed as a contact-breaker. It consists of a circular wooden disc placed between the poles of a horse-shoe magnet, having a deep channel turned in it so as to form a cup. This cup is divided into 2 parts by a wooden bridge, the ends of which come opposite to the poles of the magnet. A brass pillar rises up the centre of the bridge, supporting on its top an iron bar wound with insulated wire, the ends of which come down into the cup, and are of such a length, that when the iron bar is rotated, they will just pass over the bridge without touching it. This bar, or electro-magnet, as it really is, has a pointed pin projecting from its underside, which fits into the brass pillar, allowing the bar to rotate with very little impediment from friction. The 2 semi-cups are filled with mercury, which will stand up above the top of the bridge, the latter thus causing a sort of trough between them.

The 2 wires from the electrodes of a battery are put into the mercury, and the rotating bar is moved round, so that it may stand across instead of in the line of the bridge. As soon as this is done, the wires from the iron bar will touch the mercury, and the battery current will circulate round the bar and convert it into an electro-magnet. The N. and S. poles of the horse-shoe magnet will attract dissimilar poles, produced in the iron bar by the action of the battery current, and draw them round until they are opposite the 2 poles of the horse-shoe magnet. This operation will also carry the wires out of the mercury; communication with the battery will be interrupted; and consequently the electro-magnet will lose all its properties. But the impetus it acquired by its partial rotation will carry it a little beyond the line of the bridge, and this will bring the points of the wires again into the mercury, though not in the same semi-cups as before; the battery current therefore flows through the wire on the iron bar in the opposite direction, consequently the polarity acquired by the bar is opposite to that which it had before. The end of the electro-magnetised bar that is now N. is thus near the N. pole of the horse-shoe magnet, and these 2 mutually repel each other, and by this force the rotating bar is driven to a position at right angles to the bridge, and where its N. can be attracted by the S. of the horse-shoe magnet. By this alternative magnetisation and demagnetisation, an attractive and repulsive action is obtained, by means of which a rapid rotation is produced, and a contact made and broken twice in each revolution.

Though convenient for some purposes, this is not suitable for large batteries or coils. Every time the wires leave the mercury, a vivid spark occurs, and the surface of the mercury soon becomes covered with a coating of oxide. This being a non-conductor, prevents the battery current from flowing into the wire, and so interrupts the action.

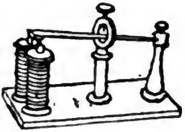

FIG. 256.

(c) Fig. 256 shows the general form of the vibrating contact-breaker. It consists of a base-board having an outer brass pillar, a central brass pillar, and an electro-magnet. The electro-magnet is fixed to the board with its poles upwards, and of the ends of the wire wound on it, one is left open, so that the battery may be connected with it, and the other passes under the board to the base of the central pillar. The outer pillar, at its upper part, holds the end of a metallic spring which passes through the ring of the central pillar to the poles of the electro-magnet. Here the end of the spring is armed with an iron plate or clapper, which should stand, when the spring is at rest, about $\frac{1}{16}$ in. above the poles of the electro-magnet. A screw passes through the ring at the top of the central pillar, and comes just into contact with the spring. The spring at this point and at the end of the screw is of platinum. When one electrode of a battery is attached to the open end of the wire of the electro-magnet and the other to the outer brass pillar, the circuit is complete. If the anode of the battery be connected with the electro-magnet, the current will enter there, circulate round it, communicate magnetic properties to it, pass under the board to the central pillar, rise up here to the ring, descend through the screw to the spring, and thence by the outer pillar to the cathode of the battery. The electro-magnet will now attract the iron clapper at the end of the spring down to itself, and by this means a separation takes place between the end of the screw and the spring, and the battery circuit is interrupted. The electro-magnet can no longer hold the clapper down; the spring thus liberated rises to the position it formerly occupied, and again comes into contact with the end of the screw that passes through the ring. As soon as this takes place, the current again flows, and the electro-magnet draws down the clapper. Thus a rapid vibration is kept up, every oscillation of the spring being associated with making and breaking contact with the battery. When applied to intensity coils, it is usual to employ the iron bundle forming the core of the coil as the electro-magnet, and to place the vibrating spring vertical instead of horizontal.

(d) Foucault's contact-breaker consists of a brass arm, which dips a platinum wire into a cup of mercury, whence it draws the point out, so breaking circuit, in consequence of its other end being attracted towards the core of the coil whenever it is magnetised; the arm is drawn back by a spring when, on the breaking of the circuit, the core ceases to be a magnet.

(e) A common contact-breaker on small coils is constructed of a piece of thin steel which makes contact with a platinum point, and which is drawn back by the attraction of the core on the passing of a current, and so makes and breaks circuit by vibrating to and fro like the hammer of an electric bell.

Condenser.—This is usually shut up in the cavity of the pedestal, though it can be separate. Its purport is to add to the energy of the current that traverses the primary wire, and consequently to increase the force of the secondary discharge. It consists of a number of tinfoil plates, separated by sheets of carefully varnished or rosinised paper, the alternate tinfoil plates being joined, thus forming 2 separate insulated series. One is connected with the pillar of the contact-breaker that carries the platinum screw, and the other with the block that holds the vibrating spring; these plates do not form part of the battery circuit, but are, as it were, lateral expansions of that circuit, on each side of the contact-breaker. The insulating sheets between the tinfoil plates thus have their electrical condition disturbed; when the battery circuit is interrupted, the plates return to their normal state, and in so doing, increase the action of the current circulating in the primary wire. The paper for separating the plates should be moderately thin, not too heavily sized, cut into pieces rather larger than is required, dipped into a solution of 1 oz. shellac dissolved in 6 oz. methylated spirit, hung up to dry for some hours, and examined; if the minutest pinhole be observed in any sheet, it must be rejected. A second coating of shellac varnish is applied, and when thoroughly dry, the paper is cut to the proper size, and preserved in a portfolio for use. For rosinised paper, ordinary tissue-paper does well, but white demy is better.

The condenser is made thus: Prepare 50 sheets of tinfoil 5 in. long and wide, 60 pieces of insulating paper 7 in. by 5 in., and 2 thin mahogany boards of rather smaller size, varnished on each side. One board is laid down, and upon it 5 insulating papers are placed, then 1 tin-foil plate, taking care that 1 in. of the latter projects over one side of the varnished paper. Another paper is laid on this, coinciding in position with the first; on this comes a second tinfoil plate, but with the overhanging part at the opposite side. This is covered with an insulating paper, and followed by the other plates in similar order. When done, 5 more papers are laid on, then the second mahogany board, and the whole is tied up with gutta-percha string. All the projecting tinfoils at one side are pressed together, also those at the other side; the condenser is then ready to be placed in the cavity of the pedestal.

Pedestal.—This is made 13 in. long 8 in. wide, and 2 in. deep. The bottom is movable, and fixed by screws or buttons. The coil is placed horizontally in the centre; holes are made in the top, in order to fix the coil in position. Other holes allow the holes of the primary wires, together with the pillars and binding screws, to be passed through, in order to attach them underneath. The contact-breaker is fixed at one end of the coil, and 2 binding screws are fitted to the same end of the pedestal; at the other end are 2 ebonite pillars, 6 in. high and about ½ in. diameter. If the ebonite be cut off about 1 in. longer than required, the extra can be turned down to a pin ¼ in. diameter, and a screw cut on its end. The holes in the pedestal are made sufficiently large to allow these pins to pass through, and the pillars can be firmly fixed by putting a nut on the under side. On top of each pillar is a binding screw with 2 holes and separate screws to each; one for the reception of an end of the secondary wire of the coil, and the other for attaching any apparatus to be employed in conjunction with the coil.

Commutator.—This is shown in Fig. 257; its use is to change the direction of the currents through the primary and secondary circuits. It consists of an ivory or ebonite cylinder 1 in. long and 1 in. diameter. Metallic axes project from each end in separate pieces, 2 brass plates ¾ in. wide are fixed to opposite sides of the cylinder, one connected with each axis. The cylinder is supported horizontally on 2 brass blocks or pillars fixed to the base-board; and 2 brass springs ris

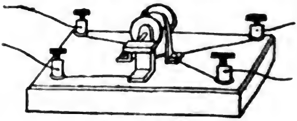

FIG. 257.

up from the board and press on the brass plates on the face of the cylinder. Of the 4 binding screws on the board, 2 are connected with the 2 springs by wires passing underneath or over the base-board, and the other 2 with the blocks carrying the axes of the cylinder. One axis projects through the block in which it rests, and on it is fitted an ivory or ebonite plate, to enable the cylinder to turn round. Two of the binding screws on the board are connected with the battery, and the other 2 with the apparatus to be operated with.

The current passes from the anode of the battery, through one binding screw of the commutator, under or over the board, to one of the springs, up this to the plate on the cylinder it is in contact with, to the first axis, through the block in which the axis rests, and out by the binding screw connected with that block to the apparatus, returning by the other spring plate and axis to the battery. When the cylinder is turned half round, without any other change in the arrangement, the current will pass in the opposite direction, still from the anode of the battery, to the first spring, but thence to the second axis.

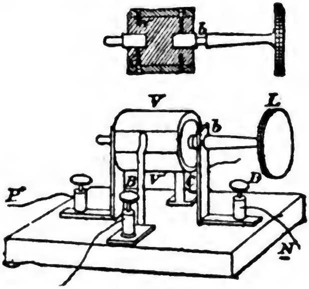

FIG. 258.

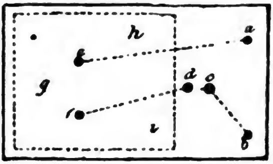

FIG. 259.

If the commutator be mounted on the pedestal, separate stand and binding screws will not be required. It is capable of being used also as a current suspender: if the cylinder be turned only ¼ revolution, the springs rest upon the interspace between the 2 brass plates, and contact is broken. This should be done while the arrangements for the secondary current are being made, to avoid receiving a shock.

Fig. 258 shows Ruhmkorff's commutator. The battery poles are connected through the ends of the axis of a small ebonite or ivory cylinder to 2 brass cheeks, V V', which can be turned so as to place them either way in contact with 2 vertical springs B C, which are joined to the ends of the primary coil.

Connections.—As to the way of making the connections beneath the base-board, it will be assumed that the commutator is not fixed on it. Then on turning the pedestal of the coil upside down, the under side will present the appearance shown in Fig. 259 : *a b* are the ends of the binding screws to which the battery is attached; *c*, pillar of the contact-breaker that carries the platinum screw; *d*, end of block that carries the spring forming the other part of the contact-breaker; *e f*, beginning and end of primary coil. A loose board *g* fits into the pedestal, as shown by the dotted lines, and is fixed about half-way up from the bottom. This is required to lay the condenser on, and to afford convenient means for attaching it. On it, at *h i*, 2 flat brass plates, about 1 in. square, are fixed, having a screwed pin in the centre of each. These are for connecting the condenser with the contact-breaker. The various screws project through the top of the pedestal fully ⅜ in. to enable nuts to be screwed over them. Strips of sheet copper, about ½ in. wide, are prepared, 2 having a hole at one end and binding screw at the other, and the third having a hole at each end. This latter is long enough to connect *b* and *c*, by dropping it over their projecting screws, and screwing a nut down tightly on the copper, securing the strip, and making the contact. The strips with binding screws are used to connect *a e* and *d f*, the binding screws securing the wires *e f*, and the holes in the copper strips enabling them to pass over the projecting screws *d a*, where they are fixed by nuts. When the anode of the battery is attached to the binding screw at *a*, and the cathode to that at *b*, the current will flow through the coil. The circuit is complete in the direction of the dotted line *ae*, through the primary coil, out at *f*, then from *f* to *d* through the contact-breaker *c*, and from *c* to *b*.

The condenser is laid on the loose board *g*, with the projecting tinfoils resting on the brass plates *h i*, a hole being punched through each set of tinfoils to admit the screw pin; a brass plate is then laid on the top of the tinfoils and by means of a nut on the screw pin they are pressed closely together. When the condenser has been fitted in place, the nuts are loosened, the top brass plate is taken off, and 2 copper strips with holes at each end are fitted over the pins. These copper strips must be long enough to connect the pin *h* of the condenser with *c* of the contact-breaker and the pin *i* with *d*; this done, the nut is screwed up again. If the condenser is not thick enough to fill the space between the loose board and the bottom, the latter is padded, so that it will press on the former, and prevent it from shifting.

(Those desiring information on more elaborate forms of induction coils should refer to the works by Norrie, published by E. and F. N. Spon, Ltd.)

* * *

INKS.

THE term "ink" is applied to a considerable number of fluid or semi-fluid compounds employed in writing, printing and for permanently marking various substances. The chief desiderata in most inks are a capacity of flowing readily from the writing instrument, while possessing sufficient body to prevent spreading and blotching, combined with depth and permanency of colour. The latter naturally depends in a great measure upon the physical and chemical characters of the article written upon, and especially upon the presence or absence of bleaching agents. The composition of inks varies as widely as do the purposes to which they are applied, hence they may be classified as follows :—

Alizarine Ink.—(*a*) A good formula for making so-called alizarine ink is the following: Powdered nutgalls, 40 parts; solution of acetate of iron, 15; gum-arabic, 10; wood-vinegar, 10; indigo-carmine, 5; and water, 100 parts. Prepare the solution of acetate of iron by pouring sufficient quantity of wood-vinegar upon scrap-iron contained in a cask, and allow it to act upon the iron for at least 8 days. Macerate the powdered nutgalls for 8 days with the 100 parts of water mixed with the 10 parts of wood-vinegar. Before mixing the strained liquid obtained from the nutgalls with the iron solution, it is necessary to ascertain whether the quantity of acetic acid present is sufficient to keep the ferrous acetate in solution. For this purpose 10 volumes of the liquid nutgall extract are mixed with one volume of the iron solution. If a clear mixture results, and of a dark-green colour in thin layers, the liquid contains enough acid; but if a black opaque liquid results, the acid is deficient. In the latter case more wood-vinegar must be very gradually and cautiously added from a measured volume, until the liquid is clear and dark green, and the requisite amount of acid, determined by this experiment, must be added to the extract of nutgalls. The gum-arabic is next dissolved in the latter, the iron solution then added, and finally the indigo-carmine, or as much thereof as may be required to produce the desired tint. ('New Remedies.')

(*b*) New Alizarine.—Boil 4 oz. Hemelon powder and 1 oz. alum powder in 1 gal. water for 15 minutes. Strain, and add 10 drops nitric acid. This writes light, but rapidly darkens.

Black Writing-ink.—The following are among the most approved recipes :—

WITH GALLS AND SULPHATE OF IRON.—(*a*) 1 lb. bruised galls, 1 gal. boiling water, 5⅓ oz. sulphate of iron (copperas) in solution, 3 oz. gum-arabic previously dissolved, and a few drops of an antiseptic, such as carbolic acid. Macerate the galls for 24 hours, strain the infusion, and add the other ingredients. (*b*) 12 oz. bruised galls macerated for a week in 1 gal. cold water, 6 oz. sulphate of iron in solution, 6 oz. mucilage of gum-arabic, and a few drops of antiseptic. (*c*) 12 lb. bruised galls, boiled for an hour in 6 gal. soft water, adding water to replace that evaporated; strain, and reboil the galls in 4 gal. more water for ½ hour; strain, and boil with 2½ gal. more water; strain, and mix the liquors. Add 4½ lb. coarsely powdered sulphate of iron, and 4 lb. gum-arabic in small pieces; agitate till the ingredients are dissolved, and filter through a hair sieve. This will make about 12 gal. of good ink.

(*d*) Good Commercial Black.—Take 1 lb. Aleppo galls and ⅓ lb. logwood chips; put them in 1 gal. of boiling soft water bruise the galls and simmer the whole for 3 or 4 hours. Strain while hot, then add 10 oz. pure sulphate of iron, 5 oz. gum-arabic, 1 oz. glycerine, 1½ oz. bruised cloves. Let stand 14 days, stirring frequently, then strain. This ink keeps well, and actually improves with age. It should be made in an enamelled vessel.

(*e*) 2 lb. bruised galls, digested in 2 qt. alcohol at a temperature of 104° to 140° F. (40° to 60° C.); when about half the alcohol has evaporated, add 3 qt. water; stir well, and strain through a linen cloth. To clarify the solution add 8 oz. glycerine, 8 oz. gum-arabic, and 1 lb. sulphate of iron dissolved in water. Stir thoroughly from time to time for a few days, allow to settle, and put up in well-stoppered bottles for preservation. The addition of too much sulphate of iron is to be avoided as causing the ink soon to turn yellow. Ink thus prepared is said to resist the action of light and air for at least 12 months, without suffering any change of colour. (*f*) Digest in an open vessel 42 oz. coarsely-powdered galls, 15 oz. gum-senegal, 18 oz. sulphate of iron, 3 dr. aqua ammoniæ, 24 oz. alcohol, and 18 qt. distilled or rain water. Continue the digestion till the fluid has assumed a deep black colour. (*g*) To good gall-ink add a strong solution of fine prussian blue in distilled water; the ink writes greenish blue, but afterwards turns black; it is said that it cannot be erased either by acids or alkalies without the destruction of the paper. (*h*) Take blue Aleppo galls free from insect perforations, 5½ oz.; bruised cloves, 1 dr.; cold soft water, 3½ pints; purified sulphate of iron, 1½ oz.; sulphuric acid by measure, 35 minims; sulphate of indigo, in the form of a thin paste, and which should be neutral or nearly so, ¾ oz. Digest together in a closed vessel, with occasional agitation, for two weeks, the galls, cloves, and water. Then filter through a piece of cotton cloth, and press out as much of the liquid as possible from the sediment. Dissolve in this completely the powdered sulphate of iron, stir in briskly the acid, then the indigo, and filter the liquid through the paper (filter-paper). In all the inks described in this section, nut-galls are introduced for the sake of their tannic acid. For this purpose they are not equalled by any other tannin-yielding substance. For cheaper inks the galls may be replaced by catechu, sumach, and a host of other astringent substances. The antiseptic (carbolic acid, etc.) is added to prevent the formation of mould.

(*i*) The following formula is said to have been in use in 1654, and to have produced an ink of great permanency, if one may judge from manuscript written by the person who is the authority for the formula: 1½ dr. coarse-powdered galls, 1½ dr. sulphate of iron, 10 dr. gum-arabic, and 1 pint soft water, are to be placed in a bottle which is to be securely stoppered and placed in the light (sunlight if possible). Stir the contents occasionally until the gum and copperas are dissolved, after which the bottle should be shaken daily. In the course of 4–6 weeks the ink will be fit for use. The addition of 10 drops carbolic acid will prevent the formation of mould.

(*j*) A good black ink can be made with the following ingredients: 2 lb. galls (in moderately fine powder), 10½ oz. copperas; 10 oz. gum-arabic; 1½ oz. sugar. Water sufficient to make 18 pints. Place the galls in an enamelled vessel, pour on it 6 pints boiling water, and allow it to macerate 2 days; transfer to a glass percolator, in the neck of which is a piece of absorbent cotton, through which allow the liquid portion to drain. When this is accomplished, pack the galls firmly, and displace with sufficient water to produce 2 gal. with that portion of the infusion which first passed. Then dissolve the gum and sugar in 2 pints water; add this and the copperas to the infusion of galls. This, after standing about 12 days, will produce a very superior ink. About 8 drops wood creosote should be added to prevent moulding.

WITH LOGWOOD.—(*a*) Boil 10 oz. logwood in 20 oz. water; then boil again in 20 oz. more water, and mix the two decoctions; add 2 oz. chrome alum, and boil again for ½ hour; and 1 oz. gum-arabic. The product is 25 oz. deep black ink. (*b*) Runge, discovered that a dilute solution of the colouring matter of logwood, to which had been added a small quantity of neutral chromate of potassium, produces a deep black liquid, which remains clear, does not deposit, and may be employed as an ink. Perfectly neutral litmus paper is not affected by it, it does not attack pens, it is very cheap, and so easily penetrates writing-paper that it cannot be removed by washing even with a sponge—in a word, it has all the properties of an excellent ink. On exposure to the air in an inkstand it sometimes decomposes very rapidly, its colouring matter being deposited in the form of large black flakes, which leave a colourless liquid above them. This gelatinisation is a great defect in this ink, particularly as one does not know the precise conditions that determine it. Different means have been proposed to prevent this action;

the best seems to be that of the addition of carbonate of sodium, recommended by Böttger. To prepare this ink take extract of logwood, 15 parts; water, 1000 parts; crystallised carbonate of sodium, 4 parts; neutral chromate of potassium, 1 part. Dissolve the extract of logwood in 900 parts of water, allow it to deposit, decant, heat to ebullition, and add the carbonate of soda; lastly, add drop by drop, with constant stirring, a solution of the neutral chromate in 100 parts of water. The ink thus obtained has a fine bluish-black colour; it flows well from the pen, and dries readily. The chrome ink powder of Platzer and the acid ink of Poncelot are imitations of the original ink of Runge. (*c*) 10 lb. best logwood is repeatedly boiled in 10 gal. water straining each time. The liquid is evaporated down till it weighs 100 lb., and is then allowed to boil in a pan of stoneware or enamel. To the boiling liquid, nitrate of oxide of chrome is added in small quantities until the bronze-coloured precipitate formed at first is redissolved with a deep blue coloration. This solution is then evaporated in a water bath down to a syrup, with which is mixed well-kneaded clay in the proportion of 1 part of clay to 3½ of extract. A little gum-tragacanth is also added to obtain a proper consistence. It is absolutely necessary to use the chrome salt in the right proportion. An excess gives a disagreeable appearance to the writing; while, if too little is used, the black matter is not sufficiently soluble. The other chrome salts cannot be used in this preparation, as they would crystallise, and the writing would scale off as it dried. The nitrate of oxide of chrome is prepared by precipitating a hot solution of chrome alum with carbonate of soda. The precipitate is washed till the filtrate is free from sulphuric acid. The precipitate thus obtained is dissolved in pure nitric acid, so as to leave a little still undissolved. Hence the solution contains no free acid, which would give the ink a dirty-red colour. Oxalic acid and caustic alkalies do not attack the writing. Dilute nitric acid reddens, but does not obliterate the characters. This ink is manufactured into ink-pencils, which give a very black writing, capable of reproduction in the copying-press, and no fading on exposure to light. (*d*) 20 parts by weight extract of logwood are dissolved in 200 parts water, and the solution is clarified by subsidence and decantation. A yellowish-brown liquid is thus obtained. In another vessel, 10 parts ammonia alum are dissolved in 20 parts boiling water; the two solutions are mixed, there being also added ⅕ part sulphuric acid, and finally 1½ part sulphate of copper. The ink should be exposed to the air for a few days to give it a good colour, after which it should be stored in well-corked bottles. (*e*) 30 parts extract of logwood are dissolved in 250 parts of water; 8 parts crystallised carbonate of soda, and 30 parts glycerine (sp. gr. 1·25) are added; lastly, 1 part neutral chromate of potash and 8 parts gum-arabic, reduced to a powder and dissolved in water. This ink does not attack steel pens, does not turn mouldy, and is very black.

(*f*) Cheap black (2*d*. per gal.).—Boil 4 lb. logwood chips in 2 gal. of water for 20 minutes. Boil (at the same time) 14 oz. powdered gum in 1 quart of water. When the logwood has boiled 20 minutes, add 4 oz. of bichromate of potash in powder and then the gum solution. Let all boil a little longer, stirring well, then cool, strain and bottle.

MISCELLANEOUS.—(*a*) Cheap black or school-board ink. 2 oz. naphthol black, ¼ oxalic acid. 1 gal. cold water (it mixes best cold). The oxalic acid may be omitted. Is a good article for cheap trade, for 1*d*. bottles or packets. (*b*) 20 gr. sugar is dissolved in 30 gr. water, and a few drops concentrated sulphuric acid are added; the mixture is heated, when the sugar is carbonised by the acid. (*c*) It is well known that aniline black, properly so called, is nearly insoluble in most chemical reagents. It is applied to textile fabrics in a pounded state, or developed on the texture or paper by the reaction of a salt of copper on hydrochlorate of aniline. It thus furnishes an intense and indelible black. But a mixture of salt of copper and hydrochlorate of aniline is not long in the air without undergoing great changes. It soon turns to green and deposits insoluble aniline black. This prevents the use of this black for flowing ink. Latterly, however, it has been found possible to prepare, with aniline and methyl, colouring substances of a bluish-black shade, so intense and soluble in water that they can be used in the preparation of beautiful black writing-ink. One of these substances is an article of commerce under the name of soluble nigrosine. It dissolves in water with a slight residue, and, without thickening, furnishes a beautiful blue-black, which is purple in reflected light, and immediately becomes intense black on paper. It is, consequently, an ink that does not change, flows easily from the pen, does not turn brown, and when dry can be again rendered fluid with a little water. It does not possess the intensity of the black from gallnut, but a softer and more velvety tone. Although prepared with a soluble salt, it is not obliterated when dry, and not easily when moistened, unless it is too thick. On the other hand, the fibre of the paper does not completely absorb this colouring substance; the residue continues as a deposit on the surface, and can be removed. This imperfection may be remedied by diluting the black with water. Acids change the characteristics into blue without destroying them, and, on account of the perfectly neutral reaction of nigrosine, this ink does not at all attack steel pens and render them unfit for use. ('Technologiste.') (*d*) Peltz, recommended:—

	Parts
Extr. logwood	100
Lime-water	800
Carbolic acid	3
Crude hydrochloric acid	25
Distilled water	600
Gum-arabic	30
Bichromate of potash	3
Distilled water to make up the weight to	1800

The ink should be made in a porcelain or enamelled iron vessel. The extract is first dissolved in the lime-water over a steam-bath with frequent stirring. To these are added the carbolic and hydrochloric acids, which change the solution from a red to a brownish-yellow colour. After half-an-hour's heating over the steam-bath, the mixture is set aside till cold, when it is strained or filtered. Lastly, the gum and the bichromate, each separately dissolved in a considerable quantity of distilled water, are added, and the remainder of the water to make up the necessary weight. This ink is of a fine red colour, which quickly turns black; it does not corrode steel pens; and if it dries, needs only the addition of water. (*e*) Joseph Ellis, of Brighton, stated to the Royal Society of Arts that, by making a solution of shellac with borax in water and pure lamp-black, an ink is producible which is indestructible by time or by chemical agents, and which, on drying, will present a polished surface, as with the ink found on the Egyptian papyri. He made such an ink, and proved, if not its identity with that of ancient Egypt, yet the correctness of the formula. (*f*) pyrogallic acid, 1 part; pulv. gum-arabic, 3 parts; ammonia vanadiate, 3 parts. These to be mixed in a mortar and sufficient water to be added. This forms an intensely black ink.

Blue-Black Inks.—(*a*) Stephen's blue-black writing fluid. This is said to be made as follows: powdered galls, 15 parts; sulphate of iron, 5 parts; iron filings, 4 parts; indigo, ½ part; concentrated sulphuric acid, 3 parts; water 200 parts. The galls are boiled in the greater part of the water, then filtered. The sulphate of iron is dissolved in the remaining water, while the indigo is dissolved in the sulphuric acid. The latter is then added to the iron solution and the iron filings added to neutralise excess of acid, After a few days strain off this mixture, and add it to the solution of galls, and the ink is finished. (*b*) Digest together for a fortnight 18 oz. bruised galls, ½ oz. bruised cloves, in 10 wine pints water. Press and filter. Add to the clear liquid 6 oz. sulphate of iron and 2 fl. dr. sulphuric acid, shaking well until solution is effected. Next add 1 oz. indigo paste, and filter if necessary. The ink must be kept in well-corked bottles, and it should be made in vessels of glass or stoneware. ('Can. Phar. Jl.')

Coloured Writing-ink. — Coloured inks may be divided into two classes, those in which the colouring matter is derived from coal-tar, and those in which it is not.

WITHOUT COAL-TAR COLOURS.— *Blue.*—(*a*) Dissolve 2 to 3 oz. sulphate of indigo in 1 gal. water. (*b*) Rub together 1 oz. oxalic acid and 2 oz. fine prussian blue, and add 1 qt. boiling water; the excess of iron in the prussian blue must first be removed by a strong mineral acid; then wash in rain-water. (*c*) 2 oz. Chinese blue, 1 qt. boiling water, 1 oz. oxalic acid, dissolve the blue in the water, and add the acid; it is ready for use at once.

Green.—(*a*) Calcine acetonitrate of chrome; dissolve the green powder in sufficient water. (*b*) Dissolve sap green in very weak alum water. (*c*) 2 oz. verdigris, 1 oz. cream of tartar, ½ pint water; boil till reduced to one-half, and filter.

Green-black.—Boil 15 parts bruised galls in 200 parts water for about 1 hour; strain; to the liquor add 5 parts sulphate of iron, 4 fine iron shavings, and a solution of ½ pint powdered indigo in 3 pints sulphuric acid. This ink flows readily; it writes green, but turns black after a few days.

Purple: (*a*) To a decoction of 12 parts Campeachy-wood in 120 parts water, add 1 part subacetate of copper, 14 parts alum, and 4 parts gum-arabic; let stand for 4 to 5 days. (*b*) To a strong decoction of logwood add a little alum or chloride of tin.

Red.—(*a*) 4 oz. ground Brazil-wood and 3 pints vinegar, boiled till reduced to 1½ pint, and 3 oz. powdered rock-alum added. (*b*) ¼ lb. raspings of Brazil-wood, infused in vinegar, for 2 to 3 days; boil the infusion for 1 hour over a gentle fire, and filter while hot; put it again on the fire, and dissolve in it, first, ½ oz. gum-arabic, then ½ oz. alum and white sugar. (*c*) Boil 2 oz. Brazil-wood in 32 oz. water; strain the decoction; add ½ oz. chloride of tin and 1 dr. powdered gum-arabic; then evaporate to 16 fl. oz. (*d*) Dissolve 1 dr. carmine in ½ dr. liquid ammonia, sp. gr. 0·880; dissolve 20 gr. powdered gum-arabic in 3 oz. water; mix the two solutions. (*e*) Mix 2000 parts Brazil-wood, 3 salt of tin, 6 gum, and 3200 water; boil till reduced to one-half, and filter. (*f*) 2 parts Brazil-wood, ½ alum, ½ cream of tartar, 16 water; boil down to ½, and filter; add ½ part gum. (*g*) To an ammoniacal solution of cochineal add a mixture of alum and cream of tartar, till the required tint is obtained. (*h*) Digest 1 oz. powdered cochineal in ½ pint hot water; when quite cold, add ½ pint spirit of hartshorn; macerate for a few days, then decant the clear portion. (*i*) Dissolve 20 gr. pure carmine in 3 fl. oz. liquid ammonia; add 18 gr. powdered gum. (*j*) Best ground Brazil-wood, 2 oz.; diluted acetic acid, ½ pint; alum, ¼ oz. Boil them slowly in an enamelled vessel for half an hour, strain, and add ½ oz. of gum. (*k*) 1 qt. of white wine vinegar, 2 oz. of Brazil-wood, and ½ oz. of alum, bottled and well shaken for a fortnight; then let simmer in a saucepan, and add ¾ oz. of gum-arabic. Let the whole stand for a few days, filter, and it will be ready for use. (*l*) Boil 4 oz. of Pernambuco-wood with 16 oz. of dilute acetic acid, and an equal quantity of water, until 24 oz. remain. Add an ounce of alum, and evaporate again to 16 oz.; add gum-arabic 1 oz. and strain; and lastly, add to the cold liquid 1 dr. protochloride of tin. (*m*) The solubility of carmine lake in caustic aqua ammoniæ is attended with this disadvantage: that in consequence of the alkaline properties of ammonia, the cochineal pigment will in time form a basic compound which, in contact with a steel pen, no longer produces the intense red, but rather a blackish colour. To avoid this evil, prepare the ink as follows: Triturate 1 oz. of pure carmine with 15 oz. of acetate of ammonia solution, and an equal quantity of distilled water, in a porcelain mortar, and allow the whole to stand for some time. In this way a portion of the alumina which is combined with the carmine dye is taken up by the acetic acid of the ammonia salt, and separates as precipitate, while the pure pigment of the cochineal remains dissolved in the half-saturated ammonia. It is now filtered, and a few drops of pure white syrup added to thicken it. In this way an excellent red drawing-ink is obtained, which holds its colour a long time. A solution of gum-arabic cannot be employed to thicken this ink, as it still contains some acetic acid, which would coagulate the bassorine, which is one of the natural constituents of gum-arabic. (*n*) Böttger rubs up carmine and silicate of soda, and then adds to this mixture a concentrated silicate solution till the whole is of sufficient consistency to write well. The product gives a very brilliant ink when dry, and dries quickly. It must be kept out of contact of air in a well-closed vessel.

Violet.—(*a*) Boil 8 oz. logwood in 3 pints water, till reduced to 1½ pint; strain, and add 1½ oz. gum and 2½ oz. alum. (*b*) Mix 1 oz. cudbear, 1½ oz. pearlash, and 1 pint hot water; allow to stand for 12 hours; strain, and add about 2 oz. gum. If required to keep, add 1 oz. spirit of wine.

WITH COAL-TAR COLOURS. — The colouring matters derived from coal-tar may all be employed for writing purposes. These inks possess bright colours, do not precipitate their colour, and dry quickly. When dried up or thickened, they can be put right by simple dilution with water. On the other hand, they are readily destroyed by chemical reagents. They must not be used with pens which have been employed in writing with other inks. They do not require any addition of gum; but if desired, 1 part dextrine may be added to every 100 parts ink. Almost all tints may be produced by mixtures, in varying proportions, of the following principal colours:—

Blue.—1 part soluble blue (night blue) in 200 to 250 parts hot water; if the ink dries with a coppery hue, more water must be added.

Green.—1 part iodine-green in 100 to 110 parts hot water. Gives a bluish-green writing; for a lighter tint, add a little picric acid.

Red.—(*a*) 1 part magenta in 150 to 200 parts hot water. (*b*) Dissolve 25 parts (by weight) safranine in 500 parts warm glycerine; then stir in carefully 500 parts alcohol, and 500 parts acetic acid; dilute in 9000 parts water, containing a little gum-arabic in solution. (*c*) Get a small quantity of magenta crystals—as many, for instance, as will lie on a sixpence, or at most on a shilling —place them in an egg-cup, and cover them with water. In a short time you will have a solution of a fine magenta colour. A little Indian ink well rubbed up, with a few drops of Judson's dye (Oxford blue) added, will intensify the colour. (*d*) Scarlet for steel pens.—Mix 1 oz. of aniline crimson in 1 gal. of water.

Violet.—(*a*) 1 part violet-blue in 200 parts hot water. (*b*) Mix together 10 parts soft water, 2 parts methylated spirit, 4 parts pure glycerine, and in this dissolve 1 part aniline violet powder. Shake or stir frequently until all are thoroughly amalgamated.

Copying-Ink.—The quality required of a copying-ink is that it shall afford one or more copies of the written matter by applying dry or damped paper to its surface, and subjecting it to more or less pressure. The best kinds of copying-ink are usually prepared by adding a little alum to an extract of logwood of 10° B. (1·075 sp. gr.), or to a decoction of the same, and then, to improve its copying power, some sugar and glycerine or table-salt is added. Such inks have a violet tint, are purple when first written, and gradually darken on the paper. The copies taken from them are at first very pale, and only slowly darken. The chief recipes for copying-inks are the following: (*a*) Boil together in 6 lb. of water, 1½ lb. nutgalls, ½ lb. copperas, 1 lb. logwood, 2 oz. gum-arabic, 1 oz. glycerine, and 1 lb. of vinegar. Boil for one hour, then filter. This copies well, but may be thickened, if required, with a little treacle.

(*b*) *Blue Black Copying-Ink.*—7¾ lb. extract of logwood, best quality; 8½ oz. crystallised sulphate of iron; 8½ oz. crystallised sulphate of copper; 1 lb. sugar (Tate's white sugar will do); 25 pints water (free from lime); 1 lb. yellow chromate of potash; 1¼ oz. indigo, finely powdered; 5 quarts water (distilled); 25 oz. by weight sulphuric acid; 60 oz. fluid basic sulphate of iron; 50 oz. fluid measure glycerine.

Method of Preparation.—Boil the 25 pints of water, and while boiling dissolve therein the extract of logwood, sulphates of iron and copper, and filter or strain off this fluid and call it No. 1.

Dissolve the yellow chromate of potash in as little water as possible, and stand this solution aside, calling it No. 2.

In an earthenware vessel put the indigo, and pour on it the sulphur (sulphuric acid) and when all intumescence has ceased and the indigo has completely dissolved, add the five quarts of distilled water (cold) and set aside, calling it No. 3.

To prepare the liquid basic sulphate of iron, put some crystals of ferreous sulphate into a bottle with twice their weight of water and a quarter their weight of nitric acid, cork and, when the crystals have dissolved, gradually add a few more at a time, until the liquid will not dissolve any more, then pour off the supernatant liquid for use. This is the liquid that gives the blue-black tone to the ink.

Add the solution (No. 2) of yellow chromate to the extract of logwood solution (No. 1), then add the glycerine, and finally put in the indigo solution, stir well and correct the redness of the mixture by adding the liquid basic sulphate of iron. The result will be a plum colour, but on exposing it to the air in open vessels for a week or two it will eventually exhibit a damson blue-black hue. Do not put more than the quantity given of liquid sulphate of iron, or the compound will turn brown.

To prepare a cheaper product, before straining the logwood solution (No. 1) dilute it with about twice its weight of water, and boil for about 15 minutes.

(*a*) Mix about 3 pints of jet-black writing-ink and 1 pint glycerine. This, if used on glazed paper, will not dry for hours, and will yield one or two fair, neat, dry copies, by simple pressure of the hand in any good letter copy-book. The writing should not be excessively fine, nor the strokes uneven or heavy. To prevent "setting-off," the leaves after copying should be removed by blotting-paper. The copies and the originals are neater than when water is used. (*d*) ½ lb. extract of logwood, 2 oz. alum, 4 dr. blue vitriol (sulphate of copper), 4 dr. green vitriol (sulphate of iron), 1 oz. sugar; boil these ingredients with 4 parts water, filter the decoction through flannel; add a solution of 4 dr. neutral chromate of potash in 4 oz. water, and a solution of 2 oz. "chemick blue" in 2 oz. glycerine. The "chemick blue" is the solution of indigo in sulphuric acid, or sulphindigotic acid. (*e*) A black copying-ink, which flows easily from the pen, and will give very sharp copies without the aid of a press, can be prepared thus: 1 oz. coarsely-broken extract of logwood and 2 dr. crystallised carbonate of soda are placed in a porcelain capsule with 8 oz. distilled water, and heated until the solution is of a deep red colour, and all the extract is dissolved. The capsule is then taken from the fire. Stir well into the mixture 1 oz. glycerine (sp. gr. 1·25), 15 gr.

neutral chromate of potash, dissolved in a little water, and 2 dr. finely-pulverised gum-arabic, which may be previously dissolved in a little hot water so as to produce a mucilaginous solution. The ink is now complete and ready for use. In well-closed bottles it may be kept for a long time without getting mouldy, and, however old it may be, it will allow copies of writing to be taken without the aid of a press. It does not attack steel pens. This ink cannot be used with a copying-press. Its impression is taken on thin moistened copying-paper, at the back of which is placed a sheet of writing-paper. (*f*) A Parisian copying-ink differs from those previously in use in having, while liquid, a more or less yellowish-red colour; but on paper it rapidly turns blue, and immediately produces a distinct blue-black copying-ink; moreover, it remains liquid a long time, while ordinary violet copying-ink soon gets thick. This kind copies easily and perfectly. The following is the method of its manufacture: A logwood extract of 10° B. (sp. gr. 1·075) has added to it 1 per cent. of alum, and then enough lime-water to form a permanent precipitate. This mass is then treated with a few drops of a dilute solution of chloride of lime (bleaching-powder), just enough being added to impart to it a distinct blue-black colour, after which dilute hydrochloric acid is added drop by drop until a distinctly red-coloured solution is produced. To this solution is added a little gum, and 1 to 1½ per cent. of glycerine. It is evident that the small quantity of chloride of calcium formed by this process greatly increases the copying power of the ink; while the exceedingly slight excess of free hydrochloric acid causes the ink to remain liquid, by holding in solution the lime and alumina lakes of logwood. When the writing dries, the acid gradually escapes, or is neutralised by the trace of alkali in the paper, so that the blue-black lake is left. It is evident that any considerable excess of hydrochloric acid must be avoided, as also the use of too much chloride of lime solution. (*g*) Add 1 oz. lump-sugar or sugar-candy to 1½ pint good black ink; dissolve. (*h*) 5½ oz. best galls, 1 dr. bruised cloves, 40 oz. cold water, 1½ oz. pure sulphate of iron, 35 minims pure sulphuric acid, ¼ oz. sulphate of indigo in thin paste, and neutral or nearly so. Place the galls, when bruised, with the cloves, in a 50-oz. bottle, pour in the water, and digest, shaking daily, for a fortnight. Filter through paper into another 50-oz. bottle. From the refuse of the galls wring out the remaining liquor through a strong clean linen or cotton cloth into the filter to avoid waste. Put in the iron, dissolve completely, and filter through paper. Add the acid, and agitate briskly; add the indigo, and shake up throroughly; pass the whole through filter-paper. Filter from one bottle to another till the operation is complete. The same ingredients may be used for common writing-ink, reducing the proportion of galls to 4½ oz. (*i*) 1 lb. Aleppo nut-galls, bruised; ½ lb. sulphate of iron (copperas), pounded; ¼ lb. gum-arabic, pounded; ½ lb. white sugar-candy, pounded; 1 gal. water. Put the above into an earthenware bottle, and keep about "new milk" warm for a week; a few cloves will prevent "moulding." Cost to make a gallon, about 2*s*. 8*d*. The bottle should have a good shaking three or four times a day. (*k*) Nigrosine ink may be used for copying, if the gelatin and bichromate are omitted. The following will be good proportions:—

Nigrosine . . .	100 grains
Water	6¼ fl. oz.
Glycerin . . .	3¾ fl. oz.

(*l*) A copying ink is obtained by reducing any good iron ink by evaporation and adding some glycerin:—

Black iron ink . . .	10 volumes
Reduce by evaporation to	6 ,,
and add	
Glycerin	4 ,,

(*m*) A good copying ink which is said to yield 3–5 good impressions, is prepared, according to Böttger, as follows:—

Extract of logwood	64	parts
Soda	10	,,
Chromate of potassium	2	,,
Glycerin	64	,,
Gum arabic	16	,,
Water	270	,,

Dissolve the extract of logwood, together with the soda in the water, add the glycerin and gum arabic, and finally add the chromate (not bichromate) of potassium dissolved in a very small quantity of boiling water. The ink may be used at once.

Engraving Inks. (*And see* LITHOGRAPHIC INKS *and* PRINTING INKS.)—Under the term "engraving inks" will be included all inks employed for engravers, whether on stone, wood, or metal.

BLACK.—(*a*) Coal-tar, 100 parts; lampblack, 36; prussian blue, 10; glycerine, 10. This ink may be used for lithography, chromo-lithography, autography, etc. (*b*) To the varnish obtained by boiling linseed-oil, as for printing-ink, is added as much best calcined Paris black as can be ground up with it. This is a litho-printing-ink. For copper-plate printing, the Paris black is replaced by lampblack. (*c*) 8 oz. mastic in tears, 12 oz. shellac, 1 oz. Venice turpentine; melt together; add 1 lb. wax, 6 oz. tallow; when they are dissolved, add 6 oz. hard tallow soap shavings, and mix; then add 4 oz. lampblack. Mix all well together, let cool slightly, pour into moulds, and cut into cakes of convenient size. This ink is suited for writing on stones. (*d*) To render (*c*) liquid, for writing and drawing on transfer-paper, it is warmed in a pot, and then rubbed down with soft water (rain or distilled water). The pen should be dipped into oil, and wiped, before use. (*e*) Pure white wax, 4 parts (best quality); white tallow, 2 parts; gum lac, 2 parts; lampblack, made from burnt rags, 1 part; oil copal varnish, 1 part. Melt the wax over a slow fire, then add gum lac crushed small, then mix in the soap in shavings, then the oil varnish for cakes. When wanted, thin with water from the cake, and for crayons cut from the paint, which must be brittle if it is good.

COLOURED.—Coloured inks are made by adding to the varnish already described certain pigments, of which the principal are as follows:—

Blue.—2 oz. celestial blue, 3 oz. marine blue.

Brown.—2 oz. burnt umber, 1 oz. rose-pink.

Green.—2 oz. mineral green, 3 oz. chrome-green.

Lilac.—1 oz. prussian blue, 2 oz. Chinese red.

Orange.—2 oz. orange-red, 1 oz. flake-white, ground up with Canada balsam, and omitting the linseed-oil varnish.

Pink.—2 oz mineral pink, 1 oz. satin-white.

Red.—5 oz. mineral orange-red, 2 oz. Chinese red.

Graph Ink.—3 dr. aniline violet; 2 dr. methylated spirit; 2 dr. mucilage of gum arabic; 2 oz. boiling water. Mix well.

Indelible Inks.—These are intended for use in cheques, vouchers, and other valuable documents, the object being to prevent tampering with the writing, and expose any such attempt if made. The following recipes have been published: (*a*) An ink that cannot be erased, even with acids, is obtained by the following: To good gall ink, add a strong solution of fine soluble prussian blue in distilled water. This addition makes the ink, which was previously proof against alkalies, equally proof against acids, and forms a writing fluid which cannot be erased without destruction of the paper. The ink writes greenish blue, but afterwards turns black. ('Pharmacist.') (*b*) A very little quantity of aniline black triturated with a mixture of alcohol and hydrochloric acid, and the liquid obtained diluted with about twice its weight of water containing a trace of gum-arabic, gives an ink, which proves indestructible alike with respect to strong mineral acids and towards concentrated lyes. ('Bayer. Ind.-und-Gew. Blatt.') (*c*) Dissolve 25 gr. of gum copal powder in 200 gr. of lavender oil by the aid of a gentle heat; then add 2½ gr. of lampblack and ½ gr. of powdered indigo. To be applied to paper with a quill pen. (*d*) Elsner prepares an ink which resists the action of bleaching agents, thus: Take equal parts of copperas and vermilion, powder thoroughly, sift, and grind the finest portions with linseed-oil; finally squeeze through linen. A thick paste is thus obtained, which can be used either for writing or printing on calico or wool. ('Les Mondes.') (*e*) Böttger prepares an ink that does not corrode steel pens by triturating 3·65 gr. of aniline black with ·22 gr. of alcohol, and 4 drops of hydrochloric acid; a porcelain mortar is employed, and the paste thus produced is mixed with 1·82 gr. of gum-arabic previously dissolved in 85 gr. of hot water. If this ink be added to an alcoholic solution of shellac (21 gr. of lac to 85 of alcohol), a black product results, suitable for colouring leather and wood. ('Dingler's Polytech. Jl.') (*f*) If the ink is to be used for writing or drawing, and there is no danger of the letters, etc., being rubbed off mechanically, printing-ink or Indian ink may be used. (*g*) Printing-ink sinks into woven fabrics to a considerable depth, and will last a long time. It is probably one of the cheapest marking-inks to be used with stencils. (*h*) In many cases Indian ink answers as well, and in some cases, as for engrossing valuable documents, it is the only safe ink, since nothing but the destruction of the document itself will be able to obliterate it. It is made by triturating 100 gr. of best Indian ink (Chinese) with very dilute hydrochloric acid (about 22 parts of absolute hydrochloric acid in 1000 parts), or with a solution of acetate of manganese in diluted acetic acid. (*i*) Another fine indelible ink, which resists all ordinary reagents, is made by means of vanadium. Vanadium and its salts are rather expensive still, although their price has fallen during the last few years to about one-tenth of what it was formerly. (*j*) An indelible aniline ink may be made thus: 100 gr. of hydrochlorate of aniline and 60 gr. of chlorate of sodium are dissolved in 3½ oz. of water, and ½ gr. of vanadate of ammonium added to the liquid, when it will soon become dark-coloured, and deposit an abundant precipitate of aniline black. This may be dried, made into a paste with powdered acacia, water, and glycerine, and used with a stencil. (*k*) 1 part of pyrogallic acid is triturated with 3 parts of powdered acacia, 3 parts of vanadate of ammonium, and a sufficient quantity of cold distilled water, in a porcelain capsule, until a uniform mixture is made. This forms a fine ink, flowing black from the pen. This may also be made into a stencil ink by using less water and adding a little glycerine. (*l*) A composition prepared by mixing well triturated carbon with an alkaline silicate (potash or soda), the following proportions answering well: lampblack, 1 part; syrupy silicate solution, 12; ammonia liquor, 1; distilled water, 38. (*m*) (1) 1 lb. extract of logwood, 1 gal. water; (2) 4 oz. sulphate of protoxide of iron, 4 oz. water; (3) ¼ oz. potassium sulphide, 2 oz. water. After dissolving the logwood by boiling, add (3) to (2), until the iron assumes a black colour; then add this compound to (*l*), and boil a few minutes; add ½ oz. potassium cyanide, which fixes the colour; for ink, add gum and alcohol. (*n*) Take 1½ part by measure of a cold saturated aqueous solution of cupric chloride, saturated at 59° F. (15° C.); 20 parts by measure of a cold saturated aqueous solution of chloride of aniline; 20 parts by measure of water; 50 parts by measure of an aqueous solution of gum-arabic (1 part by weight of gum-arabic to 2 of water) at 59° F. (15° C.); 2 parts by measure of glycerine; and some finely-powdered potassium chlorate. In mixing the ingredients, it is preferable to add the solution of chloride of aniline to that of cupric chloride first, and the other ingredients in the order named; then, when the whole has been well shaken, to add powdered potassium chlorate in sufficient quantity to saturate, at 59° F. (15° C.), the compound solution so formed. After writing, the ink is at first slate-coloured, but on warming gently it becomes black. All the solutions are to be made at 59° F. (15° C.), that is, practically, the average temperature. (*o*) Richmond's stamp cancelling inks consist of the following ingredients, namely: Eosine, aniline black, aniline blue, cupric chloride, sodium chlorate, ammonium chloride (sal-ammoniac), glycerine, lampblack, water, and oil. These substances are taken in the following proportions: Eosine, 1 part; aniline black, 4; aniline blue, 2; cupric chloride, 1: ammonium chloride, 3; sodium chlorate, 2; and of the remaining ingredients a sufficient quantity to bring the ink to the proper consistency for the use for which it is intended. The ingredients are thoroughly incorporated by grinding or stirring, when the composition is ready for use. The ink described is absolutely indelible. Stamps cancelled therewith are effectually destroyed, and the fraudulent alteration of matter written therewith is impossible. The rationale of the operation of the ink is as follows: Besides having as an ingredient aniline black, it embodies also the substances necessary to produce that colour—to wit, an aniline, an oxidising agent, add a cupric salt. The reaction of these substances is, however, retarded by the oil, which also forms a part of the ink. As a consequence, the aniline black, which is a product of the reaction of the ingredients of the ink, is partly formed within the body of the stamp paper. In preparing the composition for ordinary writing-ink, the oil and lampblack are preferably omitted, a small portion of gum-arabic being added in their stead, the latter subserving the same end as the oil. To prevent moulding, a small proportion of some antiseptic agent, such as salicylic acid, may also be added. The novelty consists essentially in such a compound as contains the ingredients for forming aniline black, and for retarding the reaction sufficiently to defer its completion until after the ink shall have been applied to the paper or surface upon which it is to be used. (*p*) Triturate 1¾ grm. aniline black with 60 drops strong hydrochloric acid and 42–43 grm. strongest alcohol; then add to it a hot solution of 2½ grm. gum-arabic in 170 grm. water. This ink attacks steel pens but little. It is not destroyed either by strong mineral acids or by strong lye. If the first alcoholic solution of aniline black be diluted with a solution of 2½ grm. shellac (instead of gum-arabic) in 170 grm. water, an ink is produced which may be employed for writing on wood, brass, or leather, and which is remarkable for its deep black colour.

Indian Ink.—The peculiar ink employed by draughtsmen is termed "Indian," because the best qualities have always come to us from India and China. The Chinese mode of manufacture is as follows: In some parts of N. China, the lampblack, which forms the foundation of the ink, is prepared much in the same manner as in Europe. In other districts the following method prevails: The furnaces are built upon the ground, with a length varying from 8 ft. to 40 ft., or even 50 ft., and with a mouth about 2 ft. in diameter. The material generally used is pine, or other resinous wood, or the resin itself, which is burned at the mouth of the furnace. Only the black deposited at the extreme end of the furnace is used for the finest ink, all the remainder being proportionately coarser. The fineness of the grain depends also upon the slowness of the combustion. The very finest black is said to be derived from pork-fat; the next from oils and other kinds of grease. The smoothness of the ink is likewise largely dependent upon the careful sifting of the black through silken bags or sieves. The first operation in compounding the ink is to soak a quantity of the excellent glue made from buffalo hide; when thoroughly swollen, it is set aside, and will keep in this state for several days. For use, the glue is melted in an iron pot, and as much lampblack is added as will produce a soft paste. This paste is very carefully kneaded by hand. A small quantity of pea-oil is then added, and the whole is maintained at a temperature of 130° to 140° F. (54° to 60° C.), until the paste is found to be perfectly homogeneous. It is then poured out in the form of flat cakes, weighing 1 lb. to 2 lb. each, and is left in that condition for many days to "ripen." It often happens, when the weather is hot and damp, that the cakes become covered with mould; but this does not seem to produce any ill effect. While one set of workmen manufacture the paste, another set fashion it into the familiar forms met with in commerce. The latter sit at a bench, with a small brazier beneath; the workman warms a piece of the paste, kneads it vigorously in his hands, presses it into a mould, and places the latter under a long lever, on the end of which he sits, so as to compress the ink forcibly for some seconds; he fills another mould in the meantime, and so the operation progresses. The moulds are made of wood, the characters to be impressed upon the cakes being engraved also on wooden dies. One of these dies is dropped into a cavity in the bottom of the mould, while another is laid on the top of the paste in the mould. Common qualities are often pressed into large moulds with several partitions, so that the cakes, when dry, can be easily broken off from each other. For wholesale manufacturing purposes, the best is simply rolled, and the sticks, perforated at one end, are strung together in bunches of ½ doz. to 1 doz. The drying of the cakes occupies 5 to 6 days, according to the temperature. Their high polish is due to brushing over with a hard brush impregnated with tree-wax (probably that secreted by *Coccus Pe-la*, on the branches of *Fraxinus chinensis*), which has the additional effect of preventing the ink soiling the hands when they are moist. The peculiar odour possessed by the finest ink is produced by mixing a small quantity of musk, or of Borneo camphor, with the paste while hot. The common qualities are unscented. The Japanese make ink in the same way, but it is inferior to the Chinese product, as, though the glue and gelatine are equally good, less care is taken in the preparation of the lampblack. The finest ink should be slightly brown in tint; when quite black, bluish or grey, it is inferior. A stick of fine ink gives a clear, sharp sound when struck; if the tone be dull, the ink is not homogeneous. The heaviest ink is the best; it improves in colour and brilliancy by age. The chief test of good ink is that it will produce a tint of any depth, without the slightest appearance of irregularity. Some cakes are worth 5*s.* to 6*s.* each.

There are several cheaper home-made imitations of the Chinese ink, besides some recipes for improving the qualities of the latter. They are chiefly as follows: (*a*) To improve Indian ink for drawing, so that even the thickest lines will dry quickly, add 1 part of carbolic acid to 80 of the ink. If, by mistake, too much has been added, it may be rectified by putting in more Indian ink. If the mixture is properly performed, the ink is as easy to draw with as it is without carbolic acid, but dries quickly, and may even be varnished without discharging. (*b*) For making a deep-black Indian ink, which will also give neutral tints in its half shades, rub thoroughly together 8 parts lampblack, 64 parts water, and 4 parts finely-pulverised indigo. Boil the mixture until most of the water has evaporated; then add 5 parts gum-arabic, 2 parts glue, and 1 part extract of chicory. Boil the mixture again till it has thickened to a paste; then shape it in wooden moulds which have been rubbed with olive or almond oil. (*d*) Most of the black Indian ink met with in commerce possesses the disadvantage that it blots when a damp brush is passed over it; or, as draughtsmen say, "it does not stand." The addition of alum does but little good; but bichromate of potash accomplishes the object by rendering insoluble the glue which the ink contains, and thus making the ink permanent. The bichromate of potash possesses a deep yellow (almost red) colour, but does not at all injure the shade of the ink, as 1 per cent. of it in a very fine powder, intimately mixed with the ink, is sufficient. The bichromate must always be mixed with the ink in a dry state, otherwise the latter might lose its friability in water. A drawing which has been made with this ink in the dark, or by artificial light, must be exposed to sunlight for a few minutes, which renders the bichromated glue insoluble in water. Draughtsmen who cannot provide themselves with such ink, make use of a dilute solution of bichromate of potash in rubbing up the ink. There is no danger of the yellow penetrating the paper if the ink is thick enough. (*e*) The greater part of the ink now sold as Indian ink consists of fine lampblack and glue. Purify fine lampblack by washing it with a solution of caustic soda, dry, and make it into a thick paste with a weak solution of gelatin containing a few drops of musk essence and about half as much ambergris; mould, and dry. Instead of gelatin the following solution may be used: Seed lac, 1 oz.; borax, ¼ oz.; water, 1 pint; boil until solution is effected, and make up with water to 1 pint. (*f*) A substance much of the same nature and applicable to the same purpose as Indian ink may be formed in the following manner: Convert 3 oz. isinglass into size by dissolving it over a fire in 6 oz. soft water; dissolve 1 oz. Spanish liquorice in 2 oz. soft water in another vessel over a fire; grind up on a slab with a heavy muller, 1 oz. ivory-black with the liquorice mixture; add this compound to the isinglass size while hot, and stir well together till thoroughly incorporated. Evaporate away the water, and then cast the remaining composition in a leaden mould slightly oiled, or make it up in any other convenient way. This composition will be found quite as good as the genuine article. The isinglass size mixed with the colours works well with the brush. The liquorice renders it easily dissolvable on the rubbing up with water, to which the isinglass alone would be somewhat reluctant; it also prevents it cracking and peeling off from the ground on which it is laid. (*g*) Mix finest lampblack with a solution of 100 gr. lac and 20 gr. borax in 4 oz. water. (*h*) Grind the finest lampblack to a paste with a very weak solution of potash. It is then diffused through water rendered slightly alkaline; collected, washed with clean water, and dried. The dry powder is levigated to a smooth, stiff paste with a strong filtered decoction of carrageen (Irish moss), or of quince seed. A few drops of essence of musk, and about half as much essence of ambergris, is added by way of perfume towards the end of the operation; after which it is moulded into hot cakes, and ornamented with Chinese characters, and devices as soon as they are dry and hard. (*i*) A good Indian ink may be made from the fine soot from the flame of a lamp or candle, received and collected by holding a plate over it. Mix this with the size of parchment, and it will be found to give a good deep colour. Burnt rice has been by some considered a principal ingredient in the genuine Indian ink, with the addition of perfumes or other substances not essential to its qualities as an ink. (*l*) Calcined lampblack, 100 oz.; boghead shale black, in impalpable powder, 50 oz.; indigo carmine, in cakes, 10 oz.; carmine lake, 5 oz.; gum-arabic (first quality), 10 oz.; purified oxgall, 20 oz.; alcoholic extract of musk, 5 oz. The gum is dissolved in 50 to 60 oz. of pure water, and the solution is filtered through a cloth. The indigo carmine, lake, lampblack, and shale black, are incorporated with this liquor, and the whole is ground upon a slab with a muller in the same manner as ordinary colours; but in this case the grinding takes much longer. When the paste is thoroughly homogeneous, the oxgall is gradually added, and then the alcoholic extract of musk. The more the black is ground the finer it is. The black is then allowed to dry in the air, until it has acquired sufficient consistency to be moulded into cakes, which in their turn are still further dried in the air, out of the reach of dust. When quite firm, these cakes are compressed in bronze moulds, having appropriate designs engraved upon them. The moulded ink is then wrapped in tinfoil, with a second envelope of gilt paper. The ink which has been prepared in this manner possesses all the properties of the real Chinese article. Its grain is smooth, it flows very well, mixes perfectly with many other colours, and becomes so firmly fixed to the paper, that other colours may be spread over it without washing it out. (Riffault.)

Invisible or Sympathetic Ink.—The terms "invisible" and "sympathetic" are applied to any writing fluid which leaves no visible trace of the writing on the paper, until developed by the application of heat or chemical reagents. They have been suggested (somewhat inpractically it must be owned) for use on post-cards. They are principally as follows: (*a*) Solution of sugar of lead in pure water leaves no trace of writing when dry; the written characters held over a jet of sulphuretted hydrogen are developed of an intense black colour. (*b*) Nitrate of the deutoxide of copper in weak solution gives an invisible writing, which becomes red by heating. (*c*) Chloride of copper in very dilute solution is invisible till heated. To make it, dissolve equal parts of blue vitriol and sal-ammoniac in water. (*d*) Nitrate of nickel and chloride of nickel in weak solution form an invisible ink, which becomes green by heating, when the salt contains traces of cobalt, which usually is the case; when pure it becomes yellow. (*e*) Chloride of cobalt in properly-diluted solution (25 gr. to the oz.) will produce a pink writing, which will disappear when thoroughly dry, become green when heated, disappear when cold, and pink again when damp. When often or strongly heated, it will at last become brown-red. (*f*) When the solution of acetate of protoxide of cobalt contains nickel or iron, the writing made by it will become green when heated; when it is pure and free from these metals, it becomes blue. (*g*) Bromide of copper gives a perfectly invisible writing, which appears very promptly by a slight heating, and disappears perfectly by cooling. To prepare it, take 1 part bromide of potassium, 1 part blue vitriol, 8 parts water. It is better also to discolor the blue vitriol with 1 part alcohol. (*h*) Write with a solution of paraffin in benzol. When the solvent has evaporated, the paraffin is invisible, but becomes visible on being dusted with lampblack or powdered graphite, or smoking over a candle-flame. (*i*) Writing with iodide of potassium and starch becomes blue by the least trace of acid vapours in the atmosphere, or by the presence of ozone. To make it, boil starch, and add a small quantity of iodide of potassium in solution. (*j*) Sulphate of copper in very dilute solution will produce an invisible writing, which will turn light-blue by vapours of ammonia. (*k*) Soluble compounds of antimony will become red by sulphide of hydrogen vapour. (*l*) Soluble compounds of arsenic and of peroxide of tin will become yellow by the same vapour. (*m*) An acid solution of chloride of iron is diluted till the writing is invisible when dry. This writing has the remarkable property of becoming red by sulphocyanide vapours (arising from the action of sulphuric acid on sulphocyanide of potassium in a long-necked flask), and it disappears by ammonia, and may alternately be made to appear and disappear by these two vapours. (*n*) Writing executed with rice-water is invisible when dry, but the characters become blue by the application of iodine. This ink was much employed during the Indian Mutiny. (*o*) Characters written with an aqueous solution of iodide of starch disappear in about 4 weeks. (*p*) Dissolve 1 fl. oz. common oil of vitriol (sulphuric acid) in 1 pint soft water; stir well, and allow to cool. Write with a clean steel pen; when dry, the writing is invisible; held to the fire, it becomes indelibly black. (*q*) Writing executed with a clean quill pen dipped in onion or turnip juice is invisible when dry; when the paper is heated, the characters assume a brown colour. (*r*) Milk makes a good invisible ink, and buttermilk answers the purpose better. It will not show if written with a clean new pen, and ironing with a hot flat-iron is the best way of showing it up. All invisible inks will show on glazed paper; therefore unglazed paper should be used. (*s*) Boil nutgalls in aquavitæ; put some Roman vitriol and sal-ammoniac to it, and when cold dissolve a little gum-arabic, and it will, when written with, vanish in 24 hours. (*t*) Burn flax so that it may be rather mouldered than burned to ashes, then grind it with a muller on a stone, putting a little aquavitæ to it, then mix it with a little weak gum-water, and what you write, though it seem fair, may be rubbed or washed out. (*u*) Widemann communicates a new method of making an invisible ink to 'Die Natur.' To make the writing or drawing which has been made upon paper with the ink appear, it is sufficient to dip it into water. On drying, the traces disappear again, and reappear by each succeeding immersion. The ink is made by intimately mixing linseed-oil, 1 part; water of ammonia, 20; water, 100. The mixture must be agitated each time before the pen is dipped into it, as a little of the oil may separate and float on top, which would, of course, leave an oily stain upon the paper.

Lithographic.—1½ lb. shellac, 1 lb. mastic in tears, 2 oz. Venice turpentine. Melt these together, and add 2 lb. wax, ¾ lb. tallow, and continue to heat. When sufficiently fluid, add ¾ lb. hard tallow soap in shavings. Let the whole combine, and finally add ½ lb. lampblack. Mix well, cool a little, then pour into moulds or on to a slab to be cut up.

Lithographic Printing Ink.—The apparatus required for boiling the oil for making this ink consists of a boiling vessel wider at the top than the bottom and large enough to hold double the quantity of oil to be boiled at one operation. It should have a rim at the top to catch any oil that overflows in boiling which, if allowed to boil over into the fire, would cause a conflagration. The boiling vessel should also be arranged so that it can readily be lifted away from the source of heat should it catch alight, for linseed-oil in boiling swells up considerably owing to the escape of aqueous vapour generated from the albuminous matter inherent in raw oil, and when once the oil begins to rise it will continue to do so until it has all flowed out of the vessel, unless the temperature of the oil be lowered; to do this you must either rake out the fire, or remove the vessel from the source of heat, or throw some clean *dry* sand (not damp, or an explosion would occur, i.e. the oil would be spirted out of the vessel) into the oil; this will cool it down quickly.

The boiling vessel should also be provided with a lid or cover that fits closely, and can be quickly and easily put on to extinguish any flame should the oil ignite.

Red Brown Lithographic Ink.—4 parts mutton tallow, 4 parts curd soap, 4 parts yellow wax, 3 parts orange shellac, 2 parts mastic resin. For colouring matter take sufficient o a compound prepared by mixing dry powder: 15 parts prussian brown 1 part vermilion, 1½ lampblack. A parts are by weight. Melt together the tallow, soap, and wax, and while almost hot enough to ignite, gradually work in the mastic resin, in fine powder, and when this has all incorporated, add the shellac, and directly it has become homogeneous by mixing well (you must keep the compound hot enough to melt these readily or it will form in lumps and not unite with the other ingredients), then add the colouring matter, and cut up into discs or cakes. When it has set hard enough for use, the ink is rubbed down in lavender oil (oil of spike lavender is the cheapest) or else in water, as preferred for the work in hand.

Olive Green Lithographic Ink.—The ingredients for this are identical to those for red brown. For colouring matter take 8 parts of the following: 2 parts yellow ochre, 1 part lampblack, and just sufficient indigo to produce the desired olive hue. The method of manufacture is precisely the same as for red brown ink, and this suffices to show how various colours may be prepared.

Marking-Ink.—The use of marking-ink is for writing on textile fabrics; it must therefore be proof against the action of hot water, soap, alkalies, etc. The chief recipes are: (*a*) 20 parts potash are dissolved in boiling water, 10 parts finely-cut leather-chips, and 5 parts flowers of sulphur are added, and the whole is heated in an iron kettle until it is evaporated to dryness. Then the heat is continued until the mass becomes soft, care being taken that it does not ignite. The pot is now removed from the fire, and water is added; the solution is strained, and preserved in bottles. This ink flows easily from the pen. (*b*) Triturate 1·75 dr. aniline black with 240 drops strong hydrochloric acid and 42 dr. strong alcohol. The mixture is diluted with a hot solution of 2·5 dr. gum-arabic in 170 dr. water. This ink does not attack steel pens, and is destroyed neither by mineral acids nor by caustic alkalies. (*c*) Permanent: Dissolve 4 parts of nitrate of silver in 10 parts of liquid ammonia. Dissolve 5 parts gum-arabic, 6 parts carbonate of soda (in crystals) and 2 parts of sap green, in 8 parts of distilled water. Mix the two solutions and use. (*d*) Indelible: 1 oz. crystallised nitrate of silver, 1½ oz. carbonate soda crystals, 160 gr. tartaric acid, 2 oz. liquid ammonia (or sufficient), 80 gr. aniline black, 5 dr. glycerine, 8 oz. distilled water. Dissolve the nitrate of silver and carbonate of soda separately in 3 oz. distilled water, mix the solution, collect and wash precipitate well with distilled water; now introduce precipitate (moist) into a wedgwood mortar, and add to it the tartaric acid dissolved in 1 oz. distilled water, stir until effervescence ceases, then introduce liquid ammonia enough to dissolve precipitate. Having dissolved aniline black in 1 oz. boiling water, add it to above, then add glycerine and distilled water enough to make the product 8 fluid oz. (*e*) Jet black aniline: 10 oz. aniline oil, 1 oz. cupric chloride crystals, ¼ oz. pulverised ammonia chloride. Put the aniline oil in a white enamelled vessel and gradually add the copper chloride and by the aid of a little heat dissolve, stirring with a glass rod. Now add the ammonia chloride, stir well, and lastly, add 3 oz. acid hydrochloric. Stir till all is dissolved, and let cool. It is now ready for use, but it is best to keep it in bulk a few weeks, as it does not have its jet black colour at first. (*f*) Indelible: E. Johanson, St. Petersburg, gives the formula for a convenient ink for marking clothing by means of a stamp: 22 parts carbonate of soda are dissolved in 85 parts glycerine, and triturated with 20 parts gum-arabic. In a small flask are dissolved 11 parts nitrate of silver in 20 parts officinal water of ammonia. The two solutions are then mixed, and heated to boiling. After the liquid has acquired a dark colour, 10 parts Venetian turpentine are stirred into it. The quantity of glycerine may be varied to suit the size of the letters. After stamping, expose to the sun or apply a hot iron. ('Pharm. Rec.') (*g*) 22 parts carbonate of soda are dissolved in 25 parts distilled water; also 17 parts nitrate of silver in 42 parts ammonia; 20 parts gum are then macerated into 60 parts water, and mixed with the soda solution ; the nitrate of silver solution is then added, together with 33 parts sulphate of copper. The ink writes a rich blue. (*h*) Dissolve 1 dr. nitrate of silver in ¾ oz. water ; add to solution as much liquid ammonia as will redissolve the precipitated oxide, with some sap green to colour it, and sufficient gum water to raise the volume to 1 oz. Letters written with this ink should be first fire-heated, and then exposed to the sun to blacken. The fabric requires no previous preparation. (*i*) Dissolve separately 1 oz. nitrate of silver and 1½ oz. carbonate of soda ; mix the solutions, and collect the precipitate on a filter ; wash well ; introduce the moist precipitate into a mortar, and add 8 scr. tartaric acid ; triturate till effervescence ceases ; add sufficient strong liquor ammoniæ to dissolve the tartrate of silver ; add 4 fl. dr. orchil, 4 dr. powdered white sugar, and 12 dr. powdered gum-arabic ; make up to 6 fl. oz. with distilled water. (*k*) Crimson marking-ink may be made by adding 6 gr. carmine to the liquor ammoniæ of (*i*) ; but it soon loses its crimson tint, and becomes black. (*l*) Dissolve 25 gr. powdered gum copal in 200 gr. lavender oil, by the aid of gentle heat ; then add 2½ gr. lampblack, and ½ gr. powdered indigo.

(*m*) Blue.

Silver nitrate . .	4	grm.
Liq. ammoniæ . .	12	,,
Sodium carbonate .	4	,,
Powdered gum-arabic .	6	,,
Cupric sulphate . .	20	,,
Distilled water . .	16	,,

Dissolve the silver salt in the ammonia, and the soda, gum and copper salt in the distilled water, and mix the two solutions. (Dorvault.) (*n*) Blue.—Mix a sufficient quantity of ultramarine with barytes (sulphate of barium, *blanc fix*), and water to produce the desired tint. It may be rendered more permanent by adding some liquid glue (solution of glue in acetic acid) or some starch paste, prepared with the addition of a little wax. ('Chem. and Drug.') (*o*) First dissolve together 8·5 parts chloride of copper, 10·6 parts salt, and 5·3 parts sal-ammoniac, in 60 parts distilled water; then dissolve 20 parts hydrochloride of aniline in 30 parts water, to which has been added 20 parts of a gum solution (made by dissolving 1 part gum in 2 parts water), and lastly, add 10 parts glycerine. These solutions are kept in separate bottles. For use, mix 1 part by bulk of the first solution with 4 parts by bulk of the second. Apply with a quill pen or small brush. The writing appears green at first, but blackens on exposure to a higher temperature. A steel pen may be used for writing with it. If the cloth, after being marked, is put into tepid soap-suds, the writing acquires a fine bluish tint. The ink should be perfectly limpid, so as to penetrate the fabric; and the solutions should be mixed only when they are to be used. (*p*) The following recipe produces a marking-ink that is quite indelible, and may be applied to the calico with a printing machine : Heat 9 parts of Venice turpentine with 4 parts olein until well incorporated. Place 10 parts soft potash soap on a slab, and work in the turpentine mixture. Now add 6 parts lampblack (previously ground and sifted), mix well, and finally add 1 part neutral extract of indigo. (*q*) The following is a recipe for an indelible red ink to use with stamps on linen : Liquefy 1 pint of balsam of copaiba by aid of heat, and gradually stir in 2 oz. of thoroughly dry white curd soap cut in thin shavings, and stir until properly diffused. Then introduce a sufficient quantity of vermilion, and stir occasionally until cold.

Marking-Ink for Parcels.—(*a*) Dissolve asphaltum, grahamite, albertite, or any minerals of this character in naphtha or oil of turpentine to a thin fluid. It dries quickly, does not spread, and the markings are nearly indestructible. (*b*) A bag marking-ink that will stand good, even when bags filled with chemical manures have been in rain and sunshine over 10 days: 1 lb. of logwood chips, boiled in 1 gal. of water 10 minutes; then stir in ⅛ oz. of bichromate of potash, and boil this 10 minutes longer; then add, when cold, ½ lb. common gum, previously dissolved, and stir well in. This will flow well from the pen, and will mark bags with either the stencil plate or block. The cost of above ink is about 6*d*. per gal. Dark blue.—(*c*) Christian Knab, Munchberg, Bavaria, makes a blue preparation good for marking trunks and boxes, because it readily combines with wood, cloth, etc., and resists the action of the weather. His process is given in the 'Deutsche Industrie Zeitung' as follows: 100 lb. of a 30 per cent. fluid extract of logwood are put in a suitable kettle, with 3 qt. alcohol, to which 2 lb. hydrochloric acid has already been added. The mixture is kept at 68° F., and well stirred until thoroughly mixed. Next he dissolves 10 lb. (yellow) chromate of potassium in 30 lb. boiling water, and adds to it 20 lb. of hydrochloric acid, stirring well, and when it has cooled to 86° F., stirs it very slowly into the mixture already in the kettle. The whole is then warmed to about 185° F. The mass, which then becomes an extract, is stirred a short time longer, and to it is added 30 lb. dextrine mixed with 20 lb. fine white earth (*terra alba*), and well stirred through. The mass, when taken from the kettle, is put into a mill where it is thoroughly worked together. It is lastly put into tin boxes, and left standing a long time to dry out.

(*d*) For marking bales.

Shellac	2 oz.
Borax	2 ,,
Water	25 ,,
Gum-arabic	2 ,,

Venetian red sufficient to colour.

Boil the borax and shellac in the water until they are dissolved, add the gum-arabic, and withdraw from the fire. When the solution has become cold, complete 25 oz. with water, and add Venetian red enough to bring it to a suitable consistency and colour. This ink must be preserved in a glass or earthenware vessel.

Neostyle or Cyclostyle Ink.—Grind aniline colour with glycerine, thinning with spirit, if desired. A few drops of oil of cloves will give a pleasant odour, if it is wished.

Printing-Ink.—The ink used by printers is compounded mainly of two ingredients, colouring matter and varnish. The former varies according to the quality and tint of the ink; the latter may be obtained by natural resinous substances, or by mixing oil, rosin, and soap.

BLACK.—(*a*) The chief colouring matter in black printing-ink is vegetable lampblack. The price of the best qualities precludes their use except for specially fine ink; nevertheless, good ink cannot be made with inferior samples. An undue proportion of lampblack in the ink will cause it to smear, however long it may have been printed, and to "set-off" during bookbinding operations. Thus the thickest inks are not the best, if the lampblack is more than the varnish can bind. Ivory-black is too heavy to be used alone; but a proportion ground up with the other ingredients makes a valuable ink for producing the best possible effect with wood-engravings. Only the best and blackest is admissible. Prussian blue, ground exceedingly fine, and used sparingly, deepens the colour of ink; in excess, it gives a cold appearance. Indigo may replace prussian blue. Perhaps the blackest tint is produced by equal quantities of each. To give a rich tone, and remove the coldness caused by indigo and prussian blue, the addition of a little Indian red is strongly recommended.

The natural resinous substances employed as a source of varnish are balsam of copaiba and Canada balsam. The former is superior, and when old and pure may be used without any preparation. The latter is much thicker and dries more quickly, and cannot therefore be used alone: but for a strong ink, a small proportion may with advantage be added either to the balsam of copaiba or to the artificial varnish now to be described.

The basis of the artificial varnish is linseed-oil, which should be as old as possible. Of all other oils, the only one recommended as a substitute is nut-oil. The rosin used may be either black or amber. It melts in the boiling oil, and combines with it, preventing its separation from the colouring matter and staining of the paper, and binding the ink to prevent its smearing. The properties possessed by soap, which render it such an indispensable ingredient of printing-ink, are that it causes the ink (1) to adhere uniformly to the face of the type, (2) to coat it completely with the smallest quantity, (3) to leave the face of the type clean, and attach itself to the surface of the damp paper by the action of pressure, and that repeatedly, (4) to wash easily off the type, and (5) to never skin over, however long it may be kept. For all dark inks, well-dried yellow or turpentine soap may be employed; for light-tinted inks, curd soap is preferable. Used in excess, soap tends (1) to render the colour unequal, where a large surface is printed, (2) to spread over the edges of the type, so as to give them a rough appearance, and (3) to prevent the ink drying quickly, and cause it to "set off" when pressed. It is thus opposed to the binding quality of the rosin. Its due proportion is when the ink works clean, without clogging.

The combination of these several ingredients is effected in the following manner: Into an iron vessel having 2 to 3 times the capacity of the materials it is to receive, put 6 qt. linseed-oil, and make a fire under it. After a time, the oil simmers and bubbles up, but as the temperature increases the surface resumes placidity; next it commences to smoke, and then to boil, emitting a very strong odour; as the boiling continues, a scum arises. At this stage, repeated tests should be made to ascertain whether the escaping vapours will ignite. At the moment when they will do so, the pot is removed from the fire and placed on the ground, and the contents are stirred with an iron spatula, and kept burning. The pot is covered occasionally to extinguish the flame, while samples are withdrawn to test the consistence. When drops of the oil let fall upon a porcelain surface will draw out into strings about ½ in. long, the oil is suited for ink for ordinary book-work. The flame is then extinguished by firmly replacing the cover. On removing it, there is a great escape of strong-smelling smoke, and much froth; the latter is made to subside by thorough stirring and when this is accomplished, but not before, 6 lb. of amber or black rosin is gradually introduced and stirred in. When the rosin is dissolved, 1¾ lb. of dry brown or turpentine soap, in slices, is stirred in gradually and cautiously, as it froths copiously. When all the soap is in, and the frothing has ceased the pot is returned to the fire till its contents boil, constant stirring being maintained. This completes the varnish. Into an earthenware pot, or a tub, of sufficient capacity, is put 5 oz. of prussian blue or indigo, or the two combined, then 4 lb. of the best "mineral lampblack," and 3½ lb. of good lampblack; next add the varnish by degrees while warm, stirring meantime and until all the ingredients are thoroughly mixed; finally pass it through a levigating mill, or between the stone and muller, and reduce it to impalpable fineness. (*b*) A fine, intensely black, strong ink, without the use of oil and rosin, may be made in the following manner: 2 oz. balsam of copaiba, 3 oz. lampblack, 1¼ oz. indigo or prussian blue, or equal proportions of each, ¾ oz. Indian red, 3 oz. dry turpentine soap, ground between a muller and a stone to impalpable fineness. This is an excellent ink for giving good effect to highly-finished wood-engravings. (*c*) Good cheap printers.—Dissolve 45 lb. colophony gum and ½ lb. yellow soap over fire, then remove, and add 25 lb.

paraffin and 15 lb. lampblack. Grind through a colour mill while warm. (*d*) *Printing-Ink to dry with a Gloss, for Litho Printers.*—To each 7 lb. of printing ink, add ¼ lb. Canada balsam and 2 oz. balsam copaiba. (*e*) In Germany an ink, prepared as follows, has been used, and is said to yield a very clear and fine impression when properly prepared: Venice turpentine, 2¼ oz.; soap, in thick paste, 2½ oz.; oleine, rectified, 1 oz.; carbon black, 1¼ oz.; Paris blue, ¼ oz.; oxalic acid, ⅛ oz.; water, ¼ oz. The three last ingredients are mixed into a paste. The turpentine and oleine are mixed at a gentle heat, the soap and carbon then introduced, and, after cooling, the blue paste is added, the whole being ground beneath a muller to a very fine and smooth paste. (*f*) Kercher and Ebner's printing-ink is prepared by first dissolving iron in sulphuric, hydrochloric, or acetic acid. Half the solution is oxidised by means of nitric acid, after which the two halves are mixed, and precipitation is produced by the oxide of iron. The precipitate is filtered, washed, and mixed with equal parts of tannic and gallic acid, which produces a black bordering on blue. The black is washed and dried, then mixed with linseed-oil, and an ink is obtained suitable for printing, lithography, and wood or metal engraving. (*g*) The base of common printing-ink is a linseed-oil varnish, which sometimes possesses a disagreeable odour, and the ink made from it smells so badly as to make a freshly-printed paper an unpleasant companion for sensitive nostrils. Dr. Brackenbusch, of Berlin, proposes to overcome this disadvantage by replacing the linseed varnish with a solution of colophony (rosin) in paraffin oil. He dissolves 45 parts of fine rosin in 25 parts of paraffin oil by heating them to 176° F. (80° C.), or by mixing them with a machine at ordinary temperature. When the solution is effected, if such it may be called, 15 parts of soot or lampblack are added. (*h*) Persoz and Jeanolle make ink for letterpress-printing, lithography, and autography, from the refuse of the gasworks, from other tar, and the heavy oils of petroleum, resin, wood, etc. They say that these substances present valuable qualities for the purpose, that they mix readily with lampblack and other dry colours in powder, and that the ink made from them has the great advantage of neither penetrating the paper nor spreading; and lastly, that it may be mixed in any desired proportions with the fatty oils for certain classes. For black ink for typographic printing, the inventors use what they call evaporated tar, or liquid pitch, with lampblack and prussian blue, in the following proportions: Tar, 100 parts; lampblack, 36; prussian blue, 10; glycerine, 10. (*i*) Colophonic tar, 14 lb.; lampblack, 3 lb.; indigo, 8 oz.; Indian red, 4 oz.; yellow rosin soap, 1 lb. The colophonic tar referred to is the residuum from the distillation of rosin for rosin-oil. (*k*) Linseed-oil, 40 gal.; litharge, 4 lb.; lead acetate, 2 lb. The oil is heated to about 600° F. (316° C.) for 48 to 65 hours, according to quality of varnish required, the lead salts being added as driers. To each gallon of this varnish, 4 lb. of gum copal is added and dissolved. For common news ink, the proportions are as follows: Of the above varnish, 15 lb.; rosin, 10 lb.; brown rosin soap, 2 lb.; lampblack, 5½ lb. (*l*) A fine ink, suitable for use with rubber type, is prepared from soluble nigrosine, 1 oz.; pure glycerine, 4½ oz.; white curd soap, ¼ oz.; water, q.s. The nigrosine, finely powdered, is mixed into a stiff paste with the water, hot, and after standing a few hours, this is mixed with the glycerine and soap, and the paste is rubbed down with a muller on a hot stone slab. (*m*) By the process of C. T. Bastand spent cotton waste is made to yield up all the oil and greasy matter contained in it, the latter being subsequently converted into printers' ink. Cotton waste, when spent—that is to say, used up—is full of refuse oil and grease.

Bastand places this spent cotton waste

in a closed cylinder heated by steam by means of an interior coil. He then pumps a solution of bisulphide of carbon into the cylinder containing the waste, upon which the chemical acts, separating the oil and grease. In their combined state, the bisulphide solution and oil are then run into another steam-heated cylinder. Here the bisulphide becomes vaporised, and passes thence to condensers, and is finally run into a store tank, to be used over and over again, the loss of bisulphide being very small. The cotton waste freed from oil is washed, dried, and sold again.

The far more valuable product obtained, the oil, is run from the second cylinder into tanks, pumped thence into a copper heated by a small portable furnace, running on wheels, and freed from all moisture. It is then pumped into a second copper, where it is converted into the varnish from which printing-ink is made. When the varnish has been brought down to its proper consistency, the furnace is taken to the mixing-house, where it is incorporated with the pigments and other ingredients necessary to produce the various shades and qualities for printing-ink. When mixed the crude ink is ground in a French buhrstone mill, and, after grinding, delivered into a machine, in which it is passed between rollers a number of times, according to the quality of ink required. To obtain the lampblack used in the manufacture of printing-ink, a portion of the recovered oil is used.

('Chamber's Jl.')

COLOURED.—Printing-inks may be made in a number of colours besides black, The principal are the following:—

Blue.—(*a*) Indigo gives a deep but dull blue; it is cold but permanent. (*b*) Prussian blue needs much grinding, and extra soap; it affords a deep bright colour, and is useful for making greens. (*c*) Antwerp blue is easily ground to the proper degree of fineness, makes a good ink, and works clean and well; its tint is bright and light, with a slight green tendency.

Green.—Various shades of green may be produced by suitable admixture of blues and yellows. Prussian blue and chromate of lead make a good rich green; indigo and the same yellow, a deeper, duller colour; Antwerp blue and the same yellow, a brilliant rich green. The chromate must be quite pure to ensure bright colours.

Purple.—Different shades of purple may be made by grinding together carmine or purple lake, with prussian blue.

Red.—(*a*) Carmine may be readily ground into a fine ink of brilliant colour by admixture with black ink varnish made with balsam of copaiba. It is expensive but valuable for special purposes. (*b*) Crimson lake is easily reduced by the muller; it works clean, and does not require more soap than is contained in the varnish, but it does not possess much depth. (*c*) A deeper tone than can be obtained from commercial lake may be produced in the following manner: 1 oz. best cochineal, powdered, and boiled in 1 qt. water, till the colouring matter is extracted, let the cochineal subside, and pour the liquid into another vessel; when cold, gradually add some chlorate of tin, with constant stirring, till the supernatant liquid, on standing, becomes nearly colourless; then add a little powdered alum. Assist the solution by stirring; allow to subside; pour off the excess liquid; wash the coloured residue with 3 or 4 waters, to remove the acid; and dry carefully and slowly. The addition of cream of tartar during the process will give a purple tint. (*d*) Vermilion may be used for red ink where neatness is required, as for title lines of books. The quantity varies much, and necessitates care in its proportions. It requires much soap to make it work clean. (*e*) For cheap work, such as posting-bills, red-lead may be used; it requires additional soap to make it work clean, and its colour soon changes to black. (*f*) An excellent permanent red, of rich tone, may be produced from Indian red. (*g*) Venetian red is easily ground into a smooth ink, and requires but little more soap than the varnish usually contains; is is not very intense. (*h*) 2 oz. mineral orange-red, 1 oz. Chinese vermilion; grind in printers' varnish or oil, as prepared for ordinary printing-ink.

Yellow.—(*a*) The highest yellow is obtained from chromate of lead, which is easily ground into a fine ink, works freely and well, and requires but little soap beyond what the varnish contains. (*b*) Yellow ochre is easily ground into a fine ink; it gives a useful colour, dull, but permanent.

Stamping-Ink. (*See also* RUBBER STAMPS.)—These are intended for use with rubber stamps. (*a*) Dr. W. Reissig, of Munich, makes an ink for cancelling stamps which is totally indelible, and the least trace of it can be detected chemically. It consists of 16 parts of boiled linseed-oil varnish, 6 parts of the finest lampblack, and 2 to 5 parts of iron perchloride. Diluted with ⅛ the quantity of boiled oil varnish, it can be used for a stamp. Of course it can only be used with rubber stamps, for metallic type would be destroyed by the chlorine in the ink. To avoid this, the perchloride of iron may be dissolved in absolute alcohol, and enough pulverised metallic iron added to reduce it to the protochloride, which is rapidly dried and added to the ink. Instead of the chloride, other salts of protoxide or peroxide of iron can be used. The iron unites with the cellulose and the sizing of the paper, so that it can easily be detected, even after the ink has all been washed off. Sulphide of ammonia is well adaped for its detection. (*b*) A violet ink for rubber stamps is made by mixing and dissolving 2 to 4 dr. aniline violet, 15 oz. alcohol, 15 oz. glycerine. The solution is poured on the cushion and rubbed in with a brush. (*c*) Good: Take 1 gal. of cheap beer, heat it, add 1 gal. of glycerine, and mix. Add 1 gal. of fusel oil, and mix again. Stir in 2½ oz. of aniline violet 6B conc. Strain, and it is ready for use. The foregoing is for violet. Other aniline colours may be used as pure blue O.T. (3 oz.); vermaline, for red (9 oz.), or malachite green (7½ oz.). (*d*) The following is a typical formula, the product being a black ink:—

Nigrosin . .	3 parts
Water . .	15 ,,
Alcohol . .	15 ,,
Glycerine . .	17 ,,

Dissolve the nigrosin in the alcohol, add the glycerine previously mixed with the water, and rub well together. Nigrosin is a term applied to several compounds of the same series which differ in solubility. In the place of these compounds it is probable that a mixture would answer to produce black as suggested by Hans Wilder for making writing-ink. His formula for the mixture is:—

Methyl violet . .	3 parts
Bengal green . .	5 ,,
Bismarck green .	4 ,,

A quantity of this mixture should be taken equivalent to the amount of nigrosin directed. These colours are freely soluble in water, and yield a deep, greenish black solution. We have found the aniline compound known as brilliant green to answer in place of Bengal green. ('Drug. Circ. and Chem Gaz.') (*e*) 2 oz. aniline blue, black, or violet, 2 oz. methylated spirit, 1½ oz. glycerine, 1 oz. mucilage of gum-arabic, 6 oz. treacle or golden syrup. Enough boiling water to make 16 oz. Place aniline colour (kind desired) in an evaporating dish with 6 oz. of boiling water, stir until dissolved with a glass rod, add glycerine and treacle, then mucilage, withdraw heat, and add methylated spirit, making up the product to 16 oz. with water. (*f*) The following is a good ink for use with rubber stamps: Aniline violet, 90 gr.; boiling rain-water, 1 oz.; to which is added a little glycerine and a small quantity of treacle. The quantities of the last two ingredients will vary with the season, but half a teaspoonful will be ample for the quantities of violet and water specified. (*g*) Red: Dissolve ¼ oz. of carmine in 2 oz. of strong water of ammonia, and add 1 dr. of glycerine and ¾ oz. of dextrine. (*h*) Blue: Rub 1 oz. of prussian blue with enough water to make a perfectly smooth paste; then add 1 oz. of dextrine, incorporate it well, and finally add sufficient water to bring it to the proper consistence. (*i*) For linen and cotton: Dissolve 1 part of asphaltum in 4 parts of oil of turpentine, and add lampblack, or blacklead, in fine powder, in sufficient quantity to render the ink of a proper consistence for printing with types. (*j*) The cushions or pads generally used in connection with rubber stamps require fresh supplies of ink from time to time; but lately a cushion has been devised which will give off colour "permanently," i.e. until it is all used. This consists of a box of wood, or other material, filled with an elastic composition saturated with a suitable colour. The cushion fulfils its purpose for years without the material being renewed, always contains sufficient moisture, which is drawn from the atmosphere, and continues to act as a colour stamp cushion so long as a remnant of the mass or composition remains in the box or receptacle. The composition consists preferably of 1 part gelatine, 1 part water, 6 parts glycerine, and 6 parts colouring matter. The composition can also be made from a mixture of gum with borax, ordinary Chinese glue, and other similar materials. A suitable black colour for the cushion can be made from the following materials: 1 part gelatine glue, 3 parts of lampblack, aniline black, or a suitable quantity of logwood extract, 10 parts glycerine, 1 part absolute alcohol, 2 parts water, 1 part Venetian soap, ⅕ part salicylic acid. For red, blue, or violet—1 part gelatine glue, 2 parts aniline of desired colour, 1 part absolute alcohol, 10 parts glycerine, 1 part Venetian soap, and ⅕ part salicylic acid. For blue—also indigo, ultramarine, cobalt, prussian or Paris blue. For red—vermilion or carmine; and for green—aniline or other outside suitable colouring matter. (*k*) An endorsing ink, which does not dry quickly on the pad, and is quickly taken by the paper, can be obtained by the following recipe: Aniline colour in solid form (blue, red, etc.), 16 parts; 80 parts boiling distilled water, 7 parts glycerine, and 3 parts syrup. The colour is dissolved in hot water, and the other ingredients are added whilst agitating. This endorsing ink is said to obtain its good quality by the addition of the syrup. ('Pap Zeit.')

Type-Writer Riband Inks.—(*a*) Although glycerine figures in many of the recipes for riband inks, owing to its non-drying (or extremely slow drying) qualities, it is not considered so perfect a vehicle as it might be. A better substance is vaseline or what is technically known as petrolatum. Melt some of this on a water bath, and rub into it while hot as much pure lampblack or powdered dropblack as it will take without becoming so dry as to be granular. When partly cool dissolve the whole, but a little at the time, in a mixture of equal parts of petroleum, benzine and rectified oil of turpentine. The finished mixture should be of the consistency of fresh oil paint. To make a trial try on end of riband. If it is too thin, add some wax; if insufficiently dark, add black; if too hard, add vaseline. Put it freely on the riband, then brush off the excess. (*b*) Heat gently 6 to 8 parts oil of cloves and dissolve in this 1 part aniline dye (soluble in oil). Any colour may be used, but the most serviceable are black and violet. (*c*) Grind 1 part gas black intimately in 5 parts oil of cloves.

Type-Writer Riband Inks, Copying.—Inks made up with aniline colour and glycerine are all copying. (*a*) Grind 1 part (by weight) of aniline colour in 6 parts glycerine. (*b*) Dissolve, with heat 2 oz. transparent soap in 8 fl. oz. of glycerine and 12 fl. oz. of water. Make a solution of sufficient aniline dye in 24 fl. oz. of alcohol, and mix all together. If too thin, increase the soap. (*c*) Dissolve 1 oz. aniline dye in 16 oz. glycerine, and add 8 oz. alcohol and 8 oz. water. (*d*) Dissolve 2 parts (by weight) of powdered aniline dye in 12 parts glycerine and add 6 parts soft soap. Warm the whole until the soap dissolves and the whole is incorporated. According to Prof. Shuttleworth, the hygroscopic properties of glycerine make it an undesirable ingredient, and the addition of glucose, soap, alcohol, or water does not improve matters. Vaseline, with or without the addition of wax, gives better results, but its consistence is appreciably affected by temperature. Prof. Shuttleworth proposes castor oil as a more suitable medium; the colouring matter may be any of the salts of the aniline series, and of these methyl violet is practically soluble in the oil mentioned. In preparing the ink, triturate the powdered colour with the oil in the mortar, the work being facilitated by the addition of a very little alcohol. A suitable formula for such an ink is that of Higgins. Castor oil, 4 oz.; carbolic acid, 1 oz.; oil of cassia, 1 oz.; suitable aniline colour, 1 oz. Printing-inks may be modified for service in the typewriter by adding vaseline to make them non-drying on the riband; if it is found that they are too soft, add wax also.

Typewriter Pad Ink.—Dissolve 1 part aniline black (soluble in oils) in 6 or 8 parts of oil of cloves, by gentle heat. Apply, while warm, to the pad with a camel-hair brush. Another ink may be made by grinding in a mortar, or a mill, 1 part gas black and 5 parts oil of cloves. See that the pad is not worn beyond satisfactory use.

Moistening Typewriter Ribands.—Use oil of cloves alone for moistening dry type-writer pads, ribands, and rollers.

Inking Typewriter Ribands. — Ribands if much worn are not worth re-inking, as the ink does not improve bad texture. Clean used ribands by soaking in methylated spirit. If a single riband is to be done, it is possible to apply the ink with a tooth-brush, while the riband is bound round a sheet of tin, or a bottle, or a smooth piece of board. It is then gone over with the back of a knife, or the edge of a blunt one, to smooth the surface and equalise the coat. If re-inking is to be done regularly make a small apparatus as follows: Provide a small flat block of wood for a base and fit on this two uprights a little wider apart than the width of the riband. In each upright two holes are bored to take the spindles or pins of two small wood rollers. These rollers are easily obtained with holes through them, through which wire pins can be put. The rollers are fitted to revolve nearly touching, but, before fitting, the lower roller is to be covered with flannel. One roller must have its pin extended and bent to form a handle, which, when turned, will cause both rollers to revolve, as the covering of flannel causes the rollers to touch one another. Beneath the lower roller there must be room to slip in a piece of marble or metal covered thickly with ink, so that the revolving flannel-covered roller will come in contact, pick up, and become saturated with ink. The riband after being cleaned, is ironed out flat, then run through the inking device. It should be found properly inked at one trial, but may be passed through twice, if thought necessary. Ribands do not require inking on both sides.

Miscellaneous Inks.—*Inks for Writing on Metallic Surfaces* may be made as follows: (*a*) 1 part verdigris (acetate of copper), 1 part sal-ammoniac, ½ part soot, 10 parts water; stir well; write with a quill. (*b*) 1 gr. sulphate of copper dissolved in 20 gr. water; add 2 drops hydrochloric acid, and enough solution of gum-arabic to make the ink adhesive. To make the writing appear at once, add a little pyrogallic acid. Write with a copper pen. (*c*) Dissolve 2 oz. shellac in 1 pint alcohol, filter through chalk, and mix with finest lampblack; forms a jet-black lustreless ink, insoluble in water. (*d*) Take ½ lb. of nitric acid, and 1 oz. muriatic acid. Mix and shake well together, and then it is ready for use. Cover the place you wish to mark with melted beeswax; when cold, write your inscription plainly in the wax clear to the metal with a sharp instrument. Then apply the mixed acids with a feather, carefully filling each letter. Let it remain 1 to 10 hours, according to the appearance desired; then wash, and remove the wax. (*e*) Make a saturated solution of sulphate of copper in gum-water. Write with a quill pen. When quite dry, give the labels a coat of white hard varnish, the labels being slightly warmed before application. (*f*) Chloride of platinum, ¼ oz.; soft water, 1 pint; to be kept in glass and used with a quill pen. (*g*) Verdigris, sal-ammoniac, and levigated lampblack, of each ½ oz.; common vinegar, ¼ pint; mix thoroughly. (*f*) is the better, but rather expensive; but will do for zinc, iron, or steel.

Ink for Writing on Tin.—Dissolve 1 part of copper in 10 of nitric acid, and add to the solution 10 of water. Cleanse the tin with dry whiting, and write with a quill.

Ink for Writing on Zinc.—Cleanse the surface of the zinc by rubbing with a sponge dipped in dilute hydrochloric acid and fine sand. Next dissolve 1 oz. 4 dr. each of crystallised verdigris and sal-ammoniac in 1 pint of warm water, filter the solution after cooling, and preserve it in well-closed bottles. Pieces of zinc written on with this preparation are allowed to lie in water a few hours. They are then dried, and used without being varnished. The writing may be executed with a steel pen or a quill, the first being, however, strongly attacked by the fluid. In case the zinc appears greasy, and the writing runs together, cleanse the surface with a rag dipped in chalk. This ink is very suitable for writing labels.

Gold and Silver Inks are made as follows: (*a*) 24 leaves gold, ½ oz. bronze gold, 30 drops spirits of wine, 30 gr. honey, 4 dr. gum-arabic, 4 oz. rain-water; rub the gold with the honey and gum, and having mixed it with the water, add the spirit. (*b*) 1 part gold, 3 parts aqua regia; mix, and evaporate till all the chlorine is given off; cool, and mix well with ether; thicken with naphtha or essential oils. (*c*) The metal leaf is ground with honey until of a fine powder; it is then washed to remove the honey, and the powder is mixed with gum water for use. (*d*) For gold ink it is best to employ genuine gold-leaf, but owing to the expense this is seldom used; sometimes mosaic gold (sulphide of tin), or iodide of lead, is employed, but almost always Dutch leaf. Owing to the relatively low price of silver, genuine silver-foil is used for silver ink; false silver-foil is seldom used, and is not so good. For other metallic inks, commercial bronze powders are employed. The genuine and false foils are also sold in a finely-pulverised state; they are made from the waste of the gold-beaters by rubbing it in metallic sieves to an impalpable powder. In consequence of the beating between gold-beater's skin, it has particles of grease and other impurities attached to it, which must be removed before it can be used for ink. For this purpose the whole sheets, or the commercial bronze powder, are triturated with a little honey to a thin magma on a glass or porphyry plate with a pestle, as carefully as possible, as the beauty of the ink depends essentially on this. The finely rubbed paste is mixed into a thin glass beaker, boiled for a long time with water containing a little alkali, frequently stirred, decanted, well washed with hot water, and dried at a gentle heat. By boiling this powder with water containing sulphuric, nitric, or hydrochloric acid, different shades can be imparted. Next, a solution of 1 part of white gum-arabic in 4 parts of distilled water is mixed with 1 part of potash water glass, and triturated with the requisite quantity of purified metallic powder. Gold ink will bear more liquid than silver ink, since gold covers much better; on rough paper more metal is necessary than on sized paper; on light paper, more than on dark, to make the colour of the ink appear equally intense. In general 1 part of foil is enough for 3 or 4 parts of the above liquid. In preparing large quantities of ink, a low porcelain measure is used for transferring it to the small glass vessels where it is to be kept, and it must be continually and thoroughly stirred, so that it will always keep well mixed. It requires frequent stirring also when in use. It is best to mix the dry powder with the liquid immediately before using. The ink can be used with a common steel pen, and flows very well when writing slowly, but it is better to use a pencil. The use of potash water glass is of much importance. It greatly increases the metallic lustre on paper, prevents its looking dead, protects the writing from being discolored by the action of the atmosphere, and prevents its penetrating too far into the pores of the paper, without rendering it very viscid. Although the writing of itself possesses a high metallic lustre, it may be increased by gently polishing with a polishing steel. Inks made with mosaic gold, mosaic silver, iodide of lead, etc., are not nearly so beautiful. (C. H. Viedt.)

Inks for Writing on Glass. (*See also* ETCHING.)—(*a*) A solution of hydrofluoric acid applied to glass previously coated with wax, and the wax scratched through with a style. (*b*) 3 parts barium sulphate, 1 part ammonium fluoride, and sufficient sulphuric acid to decompose the ammonium fluoride, and make the moisture of a semi-fluid consistence. It should be prepared in a leaden dish, and kept in a gutta-percha or leaden bottle. (*c*) An ink for writing on glass, as used in the laboratory of the University of Berne, consists of a mixture of 3 parts of a 13 per cent. solution of shellac in alcohol in the cold with 5 parts of the same strength solution of borax in distilled water. The solutions should be mixed a drop at a time, and if a precipitate forms, the mixture may be heated until clear. Enough methylen blue should be added to colour it a deep blue. This makes one of the handiest inks for laboratory use, for with it notes can be made on glassware, slides, etc., which dry quickly and remain. Either a sharp-pointed stick or a pen can be used to apply it. It can be washed off.

Burnishing Ink.—4 oz. shellac, 1 oz. borax, sufficient water. Boil to the consistence of syrup, and add a few drops of strong ammonia water. A small amount of soap is sometimes also introduced. Add a sufficient quantity of this to the ink to obtain the desired result. Instead of the above, soap is often used alone, or with a trace of glycerine, ammonia, or gum-arabic.

Shoefinishers'.—Make a strong decoction of logwood, preferably in soft water, by boiling; then add green vitriol at the rate of 2 oz. to the gal., with ½ oz. each bichromate of potash and gum-arabic. Powder the last 3 ingredients, and even the logwood, if you like, as it will take the colour out quicker; or you can use the prepared extract of logwood at the rate of 1 oz. to a gal. of water.

Bookbinders' Ink.—A very good red ink may be made in the following manner: Infuse ¼ lb. of Brazil-wood raspings in vinegar for 2 or 3 days. Boil the infusion gently for an hour, and filter it while hot. Put it again over the fire, and dissolve in it, first, ½ oz. of gum-arabic, and afterwards of alum and white sugar, each ½ oz. A little alum will improve the colour. The blue is a solution of indigo or prussian blue.

Luminous.—Grind carefully together luminous calcium sulphide and very thin gum water. Writing done with this must be exposed to bright day-light each day to retain its luminosity.

Waterproof.—The basis of this is shellac. Boil 4 oz. shellac and 1 oz.

borax in 36 oz. of water, then strain. Grind colours with this, such as Indian red or vermilionette, indigo (for blue), etc. For small quantities, the colour can be rubbed in in a mortar. These inks can be used for drawing. For transparent colours use aniline dyes, which afford a great variety and brilliant tints.

Obliterated Ink, to Revive.—(*a*) Wash in warm water to remove salt, if the paper has been immersed in sea-water, and then soak in a weak solution of gallic acid, say 3 gr. to the oz. (*b*) Wash in clean water, and soak in solution of proto-sulphate of iron, 10 gr. to the oz. (*c*) Apply a solution of potassium ferrocyanide with a brush, when the writing will appear in blue, if any iron is left of the original ink. (*d*) In order to restore faded ink all that is necessary is to moisten the paper with water, and brush over the writing with a solution of sulphide of ammonium. The ink will become black immediately, from the formation of the black sulphide of iron. Of course this means of restoration is not applicable with aniline inks. ('Boston Jl. Chem.')

Falsified Writing. — Gobert has found that if writing is ever so carefully scratched out, there are still left sufficient traces of the oxide of iron in the ink to become visible in a photographic copy. Light reflected from paper that has not been written on acts in a different way on the photographic materials from that reflected from places which have been once covered with ink. By this means the genuineness or otherwise of a document can always be ascertained. (Stummer's 'Ingenieur.')

Ink Powder.—(*a*) Finely-powdered nut-galls 10 oz., sulphide of zinc (powdered) 2 oz., sulphate of iron (powdered) 4 oz., gum-arabic (powdered) 1 oz.; 1 oz. of this powder when finely sifted, added to about ½ pint of water and well shaken, will form a good ink. (*b*) 1 oz. extract of logwood (English), 48 gr. bichromate of potash, 36 oz. crystallised carbonate soda (powdered), 2 dr. gum-arabic (powdered), 16 gr. powdered indigo.

Forgeries.—If a forger has used a different ink to that used by the original writer of the document, his error can be made manifest in the following manner: Get 9 ½-oz. or 1-oz. vials, and fill separately with (1) dilute sulphuric acid; (2) concentrated muriatic acid; (3) dilute nitric acid; (4) solution of sulphurous acid; (5) solution of caustic soda; (6) concentrated solution of oxalic acid; (7) solution of chloride of lime; (8) solution of tin crystals; (9) solution of tetrachloride of tin. Take 9 quill pens, each one for its particular reagent. Now, with a rule, draw lines crossing original and suspected portions; the difference will show itself at a glance. ('Chem. Rev.')

To Render Ink Waterproof.—If the ink is prepared with a certain proportion of gelatine, the addition of a little bichromate of potash, followed by exposure to sunlight, has been recommended for rendering the ink so insoluble in water that it will not run or spread, when water-colours are used for shading the sides of the lines.

Ink Eraser.—A good ink eraser is thus made: Take 1 lb. chloride of lime, thoroughly pulverised, and 4 qt. soft water. The above must be thoroughly shaken when first put together. It is required to stand 24 hours to dissolve the chloride of lime; then strain through a cotton cloth, after which add a teaspoonful of acetic acid to every ounce of the chloride of lime water. The eraser is used by reversing the penholder into the fluid, and applying it, without rubbing, to the word, figure, or blot required to be erased. When the ink has disappeared, absorb the fluid with a blotter, and the paper is immediately ready to write upon again. Chloride of lime has before been used with acids for the purpose as above proposed; but in all previous processes the chloride of lime has been mixed with acids that burn and destroy the paper.

Action of Bleaching Agents upon Writing Ink.—It is well known that ordinary writing is easily removed, when it is acted upon by bleaching agents. Advantage is taken of this fact by unscrupulous persons desirous of altering documents, cheques, and banknotes for improper purposes. Hence the number of fugitive inks and supposed untamperable papers in use to meet this difficulty.

A curious and interesting case of supposed fraud came under the notice of the writer in the form of a document which was written upon the fly-leaf or second page of a sheet of legal paper, the margin of the first page containing the stamp, date, and watermark of a will, purporting to have been written about 20 years ago. The document or will was thus written upon paper bearing, both on stamp and in watermark, a date which gave it the semblance of age. The appearance of the document gave rise to suspicion, and I was asked if it was possible to tell the age of the writing, and if the writing had been executed at one and the same time, and if so at what time.

This was, of course, impossible, as I was not allowed to treat the document itself. I had, therefore, to make experiments upon writings, the dates of which I knew.

I selected writing 1 day, 6 months, 12 months, 2 years, 6 years, 14 years, and 22 years old, and exposed these writings to the action of a very dilute solution of ordinary bleaching powder in water. The specific gravity was about 1·001. In 6 minutes the newly written matter had disappeared; in 9–12 minutes the writing of 6 months ago had disappeared; in 20 minutes the writing of 2 years had partly disappeared; in a like time, the writing of 6 years ago was not greatly affected; 14 years ago very slightly; and 22 years hardly affected at all (indeed, old writing seems hardly affected by such a weak solution, even after hours' exposure).

Peroxide of hydrogen acts more slowly but gives more definite results. Other reagents give effects which help (although sometimes in a contrary manner to that I have indicated) to establish the fact that ordinary writing ink, which is a compound of gallic and tannic acids with proto-salts of iron, becomes more stable (presumably by oxidation), and consequently is less or more affected by chemicals which act upon the organic colouring matter of the ink. There are great varieties of writing inks, chromium and vanadium salts being sometimes substituted for the iron salts. There are also black and coloured inks prepared from coal-tar dyes; but thinking it highly improbable that any documents intended for preservation would be executed in such evanescent inks, I did not investigate their behaviour under such treatment. When ink is thus bleached or apparently removed, most of the iron contained in the compound remains mordanted with the fibres of the paper; consequently, writing so tampered with, or dealt with, can be restored by the application of gallic or tannic acid. The writing is thus reproduced almost in its original depth of colour. It is delicate work (especially in the civil legal aspect of the case to which I have referred) to determine in a reliable manner the age of any particular writing, and it is necessary that the following precautions be carefully observed:—

1. The inks must be those known as ordinary writing inks, prepared from iron and chromium salts and galls.
2. Writing dried by means of blotting paper is naturally more easily removed than writing which is allowed to dry on the surface of the paper; and light writing is somewhat more easily removed than coarse and heavy writing.
3. The bleaching solution must be exceedingly dilute, otherwise the action is so rapid and powerful that both old and new writings are removed almost simultaneously.
4. The action must be carefully watched, so as not to be too long con-

tinued. Lastly, very old writing which has become brown by age, although it resists the action of weak solutions of bleaching powder and peroxide of hydrogen, will show signs of giving way almost instantly when acted upon by dilute nitric, hydrochloric, and oxalic acids.

Although I have only made use of a well-known process and materials to obtain the results I have indicated, still I think such a simple means of detection may act as a check to frauds which are becoming only too common.

IVORY.

(*See also* CELLULOID, EBONITE, ETC.)

Bleaching Ivory.—(1) Ivory that has become yellow by exposure can be whitened by washing in a solution composed of 1 oz. nitric acid, and 10 oz. soft water; apply with a rough brush; cleanse thoroughly in clean water; (2) or by rubbing the ivory with fine pumice and water, and while damp exposing it to the sun under a glass vessel. (3) Peroxide of hydrogen is used in Sheffield to bleach the inferior ivory for knife handles. The mode of procedure is as follows: Place, say, 2 qt. of the liquid in a stone pot, adding 4 oz. liquor ammon. fort., immerse the handle, and put over a common shop stove for 24 to 36 hours; the handles are then taken out and gradually dried in the air, not too quickly, or they would split. The deep colour of the ivory is removed, and a beautiful pearly white results when polished. The ivory is previously treated with a solution of common soda, to get rid of greasy matter, and open the pores. (4) Take 2 handfuls of lime, slake it by sprinkling it with water; then add 3 pints of water, and stir the whole together; let it settle 10 minutes, and pour the water into a pan for your purpose. Then take your ivory and steep it in the lime-water for 24 hours, after which, boil it in a strong alum-water for 1 hour, and dry it in the air. (5) Slake some lime in water; put your ivory in that water, after being decanted from the grounds, and boil it till it looks quite white. To polish it afterwards, set it in the turner's wheel; and, after having worked, take rushes and pumice stones, subtile powder, with water, and rub it till it looks perfectly smooth. Next to that, heat it by turning it against a piece of linen or sheepskin leather; and, when hot, rub it over with a little whiting diluted in oil of olive; then, with a little dry whiting alone; finally with a piece of soft white rag. When all this is performed as directed, the ivory will look very white.

Cleansing Ivory. *To Remove Stains from Ivory Knife Handles.*—Put some hydrogen peroxide in an earthenware jar, just deep enough to cover the knife handles. Immerse the handles and let them stay a time (it may be three or four hours), then dry, and expose the ivory to sunlight.

To Remove Grease Stains from Ivory. Soak in best turpentine for 24 hours, then rub off with whiting. This has a cleansing and bleaching effect. The turpentine must not be allowed to soak into joints of knife handles.

To Cleanse Ivory Ornaments.—These are very quickly cleaned by brushing them with a new, not very sharp, tooth-brush to which little soap is given; then rinse the ornaments in lukewarm water. Next dry and brush a little and continue brushing until the lustre reappears, which can be increased by pouring a little alcohol upon the brush and applying it to the trinket. Should this have become yellow, dry it in a gentle heat, and it will appear as if new.

Cleansing Ivory and Bone.—The curators of the Anatomical Museum of the Jardin des Plantes, in Paris, have found that spirits of turpentine is very efficacious in removing the disagreeable odour and fatty emanations of bones or ivory, while it leaves them beautifully bleached. The articles should be exposed in the fluid for 3 or 4 days in the sun, or a little longer if in the shade. They should rest upon strips of zinc, so as to be a fraction of an inch above the bottom of the glass vessel employed. The turpentine acts as an oxidising agent, and the product of the combustion is an acid liquor which sinks to the bottom, and strongly attacks the ivory if allowed to touch it. (2) Make a thick puddle of common whiting in a saucer. Brush well out with plenty of clean water. Dry gently near the fire. Finish with a clean dry hard brush, adding one or two drops (not more) of sweet oil. (3) Mix about a tablespoonful of oxalic acid in ½ pint of boiling water. Wet the ivory over first with water, then with a tooth-brush apply the acid, doing one side at a time, and rinsing; finally drying it in a cloth before the fire, but not too close. (4) Take a piece of fresh lime, slake it by sprinkling it with water, then mix into a paste, which apply by means of a soft brush, brushing well into the interstices of the carving; next, set by in a warm place till perfectly dry, after which take another soft brush and remove the lime. Should it still remain discolored, repeat the process, but be careful neither to make it too wet nor too hot in drying off, or probably the article might come to pieces, being most likely glued or cemented together. If it would stand steeping in lime-water for 24 hours, and afterwards boiling in strong alum for about an hour, and then dried, it would turn out white and clean. Rubbing with oxide of tin (putty powder) and a chamois leather, will restore a fine gloss afterwards. (5) Well clean with spirits of wine, then mix some whiting with a little of the spirits, to form a paste, and well brush with it. It is best to use a rubber of soft leather where there are no delicate points; put a little soap on the leather, and dip into the paste, and rub the ivory till you get a brilliant polish, finish off with a little dry whiting; the leather should be attached to a flat wood surface, and rub briskly. (6) When ivory ornaments get yellow or dusky-looking, wash them well in soap and water, with a small brush to clean the carvings, and place them while wet in full sunshine; wet them two or three times a day for several days with soapy water, still keeping them in the sun; then wash them again, and they will be beautifully white. To bleach ivory, immerse it for a short time in water containing a little sulphurous acid, chloride of lime, or chlorine.

To Make Flexible.—Immerse the ivory in a solution of pure phosphoric acid, sp. gr. 1·13, until it partially loses its opacity; then wash in cold soft water, and dry. This renders ivory very flexible, but it regains its hardness if long exposed to dry air. Its pliability may, however, be restored by immersion in hot water.

To Soften Ivory.—In 3 oz. spirits of nitre, and 15 oz. of spring water, mixed together, put your ivory to soak, and in three or four days it will obey your fingers.

Mounting.—The ivory should be fastened at the four corners to a piece of cardboard for the convenience of painting on; the back of the ivory should be kept perfectly clean, as any application of gum or glue to its surface destroys the transparent quality upon which its usefulness depends. After the surface to be painted on is properly cleaned, it should on no account be touched with the fingers, as the employment of ox-gall to remove greasiness must be scrupulously avoided. An ivory palette is best adapted for miniature painting, because the tints appear on it the same as when worked on the miniature, a matter of considerable importance.

Preparing for a Miniature Painting.—It is usual to paint miniatures upon ivory which is sold prepared for the purpose by the artist's colourman, after being subjected to a bleaching process by boiling, or exposure to the rays of the sun; but the bleaching can be more expeditiously performed by placing the ivory before a good fire, which will dispel the wavy lines, if they are not very strongly marked, that frequently destroy the requisite uniformity of surface. Ivory of the best quality has but few of these wavy lines, but it is frequently expedient to employ that of inferior quality.

To Detect Defects.—By holding the ivory up to the light, it will be seen whether there are any specks or holes in it; if any exist, they will be fatal to the success of the painting. It is often necessary to remove the defects found in the ivory in the state in which it is sold. To remove the marks of the saw, scrape the surface equally in every direction with an eraser, or an old razor with a fine edge, by which the marks of the saw are removed; then, with a piece of fine cork, or a roll of paper dipped in finely pulverised and sifted pumice, or tripoli powder and water, rub the ivory with a circular motion in every direction, until the surface presents one uniform tint, but it must not appear polished; finish with a stump and a little cuttle-fish powder carefully sifted; then, with a large camel-hair pencil and water, wash the surface of the ivory, and it will be ready to receive the colours. To render the ivory perfectly flat, place it between two pieces of white paper, and subject it to pressure by placing a weight upon it.

Staining Ivory (and Bone).—*Red Ivory.* (1) Steep in good red writing ink, if not intended to be afterwards used in water, or to be washed.

(2) This red, if to be used on an article liable to contact with water, needs to be applied upon a mordant, or fixer, made as follows: aqua fortis, 2 oz.; sal-ammoniac, ¼ oz.; mix; then add tin, in powder, ¼ oz.; water 1 oz. When all are dissolved, steep the ivory or bone articles in the liquor, and allow them to dry, Afterwards boil Brazil-wood, ½ lb.; water, 1 gal.; and again steep your articles in it when at boiling heat.

Scarlet for Ivory or Bone.—Proceed as in the red, but use solution of lac dye instead of Brazil-wood.

Yellow for Ivory or Bone.—(1) For twenty-four hours soak your articles in a bath of strong chromate of potash and follow that by doing the same in one of acetate of lead. (2) Steep in a bath of nitro-hydrochlorate of tin for two hours, and afterwards boil in a decoction of fustic chips. (3) Alum, 1 lb.; water, ½ gal. Boil the ivory, etc., in this wash for half an hour, and have ready the mixture made as under: water, 1 gal.; turmeric, ½ lb.; pearlash 1 lb. Boil these, and on taking your articles from the first alum wash, plunge them in the turmeric one, and boil for half an hour. After that again boil in the alum wash to fix the colour.

Violet for Ivory or Bone.—Tin (in powder), ¼ oz.; sal-ammoniac, ¼ oz.; nitric acid, 2 oz.; water, 1 oz. Dissolve all completely, and then steep your ivory or bone in the liquor, taking care not to let it touch your hands, or it will produce painful sores and discoloration. Also avoid breathing the gas evolved from the liquor. After dipping in the above, steep the articles in a decoction of logwood.

Black for Ivory or Bone.—(1) Water, 1 gal. ; logwood, 1 lb. ; acetate of iron, ½ lb. Soak the articles in this until the colour penetrates deeply by boiling in. (2) Dissolve lunar caustic (nitrate of silver) in water to a strong solution, and steep your articles in the solution for four or five hours, and afterwards develop the colour by exposing to the sunlight. A pair of wooden tongs should be used to lift the articles out of the dye vat or bath, as the solution is injurious to the hands.

Green for Ivory or Bone. — (1) Vinegar, 1 qt. ; verdigris, 1 oz. Dissolve together, and then boil your articles in it until of the desired hue. The vessel in which the operation is made must not afterwards be used for any household purpose, for the dye is highly poisonous, and liable to penetrate any vessel in which it has been made or put.

For Bone.—(2) Sulphate of indigo, ½ oz. ; potash, ½ oz. ; water, ½ gal. Boil and steep the articles in the hot liquor, and afterwards dip into a solution of nitro-sulphate of tin, and follow that by one of a decoction of fustic.

Blue for Ivory or Bone.—(1) Boil together sulphate of indigo, ½ oz. ; potash, ¼ oz. ; water, 2 qt. ; and steep the goods in the decoction until of a deep blue. (2) Sulphate of copper, 1 lb. ; water, 2 qt. Boil together and steep your articles in the liquor in a boiling heat.

Gilding Ivory.—(1) Ivory is not so easy to gild as articles made of wood : wood, being porous, retains a portion of the gold size ; yet, on the other hand, bone or ivory may be so gilt that it shall resemble gold. Free the ivory from dirt or grease ; when quite dry, give the article a thin coat of gold size laid on evenly with a fine hair brush ; lay aside until set, which may be known by feeling whether tacky to the finger. The gold size should be just the least warm ; the article may, with advantage, be warmed before applying the gold size ; great care must be used to keep the dust from the article until gilt and quite dry. Cut the gold leaf in suitably sized pieces, and apply with the tip ; the gold leaf may then be pressed into shape with a piece of white wool. Should any part appear not gilt, apply a dab of gold size, then a piece of gold leaf. When quite dry, it may be burnished with an ivory paper-knife, or even a glass penholder, always inserting a piece of tissue paper between the burnishing tool and the gold leaf. (2) Immerse it in a solution of nitro-muriate of gold, and then expose it to hydrogen gas while damp. Wash it afterwards in clean water.

To Silver Ivory.—Pound a small piece of nitrate of silver in a mortar, add soft water to it, mix them well together, and keep in a phial for use. When you wish to silver any article, immerse it in this solution, let it remain till it turns of a deep yellow ; then place it in clear water, and expose it to the rays of the sun. If you wish to depict a figure, name, or cipher, on your ivory, dip a camel's hair pencil in the solution, and draw the subject on the ivory. After it has turned a deep yellow, wash it well with water, and place it in the sunshine, occasionally wetting it with pure water. In a short time it will turn of a deep black colour, which, if well rubbed, will change to a brilliant silver.

Etching Fluid for Ivory.—Take dilute sulphuric acid, dilute muriatic acid, equal parts : mix. For etching varnish take white wax, 2 parts ; tears of mastic, 2 parts : mix.

Cement for Ivory.—The American or Diamond cement unites pieces of ivory with great firmness, but where a white cement of nearly the same colour as ivory is required, the following modification will be found useful: (1) Dissolve 1 part of isinglass and 2 of white glue in 30 of water; strain and evaporate to 6 parts, then add $\frac{1}{30}$ part of gum mastic, dissolved in $\frac{1}{2}$ part of alcohol, and add 1 part of zinc white. When required for use, warm and shake well. The broken edges to be joined must also be warmed.

Artificial Ivory.—Make a paste of isinglass and brandy with finely ground egg-shell. While warm pour the paste into an oiled mould, and when set the substance will closely resemble ivory. It may be tinted, while in the condition of paste, as desired.

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JAPANS AND JAPANNING.

(*See also* ENAMELLING, LACQUERING, PAINTS, *and* PAPIER MACHÉ.)

THE subject of Japans and Japanning deals wholly with the application of black or coloured varnish paints to the surfaces of metal or wood by the aid of heat, this process necessitating the use of a japanning oven. Articles so treated are said to be "stoved," the process commonly being spoken of as "stoving." When a suitably varnished surface is heated for some time to a temperature of 250° to 300° F., it is found that the whole of the solvent or vehicle of the gums or resins of the varnish is soon driven off, and the gummy residue becomes semi-liquefied, in which state it adapts itself to all inequalities. When the coating becomes thick enough, it presents a glossy surface which it retains on cooling. This process of drying out and fusion secures a firm contact of the gums and resins to the surface of the substance so treated, and greatly increases the density of the coating, and this enables it to resist wear and retain its gloss satisfactorily.

The heat of a japanning oven varies from 250° to 350° F., a temperature of about 300°F. being the most usual for iron goods. As will be learned japans vary in the heat required for best results. If the japan is purchased, the makers will state the heat it requires, while this can be soon learned with shop-made material. On this account it is best to use one make or brand of japan, and make no changes after the most suitable kind is found.

A japanner's oven may be a fair sized room, or it may be as small as a cupboard. In the former case it is almost always brick-built (with iron doors), while the latter is more often of sheet-iron. If the oven is to have continuous use, an iron oven is best made with double walls to prevent waste of heat by radiation, and if the double walls having a packing of silicate cotton (slag wool) between them the results will be as economical as are obtained with a brick oven.

The heating of the oven is done by coal or gas. Gas is probably as economical as coal for small work and irregular demands, and it possesses the advantage of being very precise in results, once the burners are properly regulated. It is also possible to dispense with a chimney in many cases. For large purposes and a continuously heated oven the coal fire costs least and is almost invariably used.

In building a brick oven the furnace is arranged to come as near the centre as possible, and one or more flues pass from this under the floor and up the side walls. It is the heating of the floor, which is composed of metal plates, that is relied on to give the required temperature, but it is requisite to have a brick arch or heavy cast plate beneath the floor, just over the fire box, otherwise the floor might get red hot at this point. The red heat might not prove a fault, but it would make it next to impossible to walk in and out the oven, as the japanner has to do in ovens of any size.

To show what a simple thing a japanning oven is, the writer saw one (doing very good bedstead work in a temporary factory), which consisted of a very large $\frac{1}{8}$-in. plate wrought-iron, water cistern (purchased second-hand) placed on its side over a furnace made in a small pit. A pair of doors were fitted to the open side (which had been the top) and the whole was surrounded by rough brickwork. Flues were arranged under and terminated in a chimney. In this case the floor often became of a low red heat, but a piece of metal grating laid on the floor admitted of the man stepping to and fro, and the work turned out was as good as was required. It may be added that the heat was obtained wholly by the consumption of refuse from the woodworking machines used in making mattress frames.

In making a small oven or stove, wholly of metal and heated by gas, such as might be used for cycle frames and similar work, the following specification might be followed. The size could be 4 ft. wide, 3 ft. deep, 5 ft. high. The casing of 20 G sheet iron, preferably galvanised. The frame should be of light angle iron, drilled or punched ready for riveting together and for the sheet iron to be secured. The sides and back should be lengthened (carried down) below the bottom of the oven about 5 in., and the doors in front should come down to the same depth. This will then provide an enclosed space, 5 in. high, beneath the oven, where the burners come. A series of holes should be made around this enclosed space to admit air for combustion and to allow the products of combustion to escape. The holes for fresh air should be low, the others high. Whenever possible the products of combustion should be carried away by a flue, and when this is done the holes for fresh air (into the combustion chamber) should be confined to the front, while the flue nozzle should be at the rear. This matter requires particular consideration in small rooms or chambers, as the products of combustion from burners of large size are sufficient to cause ill effects, possibly asphyxiation, if they cannot get away freely. The same risks exist as using a geyser or gas heater in a small unventilated bath room. If connection is made with a chimney, care should be used that a strong draught does not occur through the combustion chamber, as this will have a cooling influence.

Every japanning oven should be provided with a thermometer registering up to say 400° F. (so that the ordinary temperature of 300° F., or any variation from it, can be seen plainly). The commonest plan is to simply hang this on the wall, and if the japanner is constantly putting in or taking out goods, this is sufficient, but to open the oven door solely to look at the thermometer is not economical. Thermometers can be had which, with the bulb inside, have their registering column outside, but failing one of these a narrow upright slot can be cut in the door and the thermometer hung inside, so that its tube and figures come against the slot and can be seen at a glance outside.

The japanning chamber should also be ventilated to a small degree—sufficient for the fumes to pass away by. This can be done by providing a few holes in the door, near the bottom of the chamber, and a few holes at the back (or a small pipe) near the top. In this again care must be used not to cause a draught through, or the heat will be prejudicially affected.

The gas burners should be of the blue-flame (atmospheric or Bunsen) kind, and the burner pipes should run from front to back of the oven. There may be two, three, or more, according to the size, of the oven, each being independent to admit of separate control. With an oven of the size just given there should be three burners.

It will be noted that the burners are fitted to come beneath the true bottom of the oven. Ovens have been made with the burners inside (like a cooking oven), but this will not do for proper work, although it may be economical of gas. The products of combustion, particularly the sulphur, will injuriously affect the work—even black work—while with coloured japans the effect is ruinous. On this account the bottom of the oven must be made air-tight.

Enamelling Cycles.—It is important in this, as in all japanning work, that the job be proceeded with as quickly as possible after the work is cleaned up in readiness. The first process, commonly called sweating, is to rub over the work in tar spirit with a clean rag, then put it in the oven with a full heat for about 20 minutes. When taken out and allowed to get cold the first coat of japan is put on very thin with a camel hair brush, working from end to end. It is important to note that in japanning work thin coats are the rule, for the simple reason that a thick coat, even if firm when laid on cold, will run when it first gets hot. The first coat is stoved for an hour. When cold again it must be rubbed down to a smooth surface. Pumice-stone and water are commonly used, while some favour fine glass paper, but, whatever is used, it is essential that the rubbing down be done to ensure a good result with the last coat. The second coat is done with finishing japan, and the work is put into the oven with full heat again. The time will vary according to the japan, but 1 to 1½ hours is usual. The work should be felt when the time is about right, as it is best to take the goods from the oven before the surface is quite hard. It should have just the slightest tackiness, and it will then cool hard. This affords a more elastic and less brittle finish than allowing the last coat to get hard in the oven. The foregoing is for fair quality work. For best work one more rubbing down and one more coat of japan are required. Cleanliness is very important through the whole process. When the work is cleaned it should not be touched with the hand afterwards. Wooden pegs should be inserted where convenient for handling by. All cloths for rubbing down should be clean, and when water is used the parts must be carefully dried before laying on the japan.

To give the aluminium surface that cycle frames sometimes have, give the work a coat of japanner's gold size, to which has been added a little stoving varnish, then stove until the surface is tacky. Now rub over with aluminium powder, then put back into the oven until the surface is hardened. When cool give a coat of stoving varnish and stove again.

In japanning sheet iron or tin goods, such as trunks, canisters, cans, etc., the various japans described may be used, or a general recipe may be worked to as follows. Let the colouring pigments be of the purest quality ground to a paste in oil. Thin with good turpentine and add a small quantity of japanner's gold size to bind them. The process to be then adopted is to paint the articles and subject them to a low heat for drying purposes only. They are then varnished with japanner's copal varnish and stoved for about 1½ hour at 240° F. temperature. As with black japans the different makes of varnish require a different amount of stoving for best results.

With best work, as with expensive tea trays, the stoving is extended into several hours at a lower temperature, with a view to obtaining a japanned surface with the greatest flexibility. The sheet metal has all scales removed and is rubbed down with stone until the surface is not only smooth but fairly well polished. The process does not entail using a black or coloured japan so much as providing a groundwork of the most suitable colour and then putting two or more coats of varnish on it. The temperature of the oven should not exceed 210° F., and the articles should be in about 10 hours each time. The first coat is the black japan ground described, but the quantity of varnish may be small, as this coat may dry dead. When this coat has had its stoving, it is taken out and given a coat of black japanner's varnish and stoved again. It then has one or two further coats of varnish in succession. It is necessary to rub down the small lumps which will appear after each coat, with a piece of pumice, first made flat by rubbing it on a slab of slate. Keep dipping the pumice in water. This rubbing down must be executed very lightly, or the smooth parts will be scratched. If the article is to be decorated with burnished gold, the first process, after coming out of the stove the last time, is to "rough" it. This is done with very fine pumice powder applied with some kind of corded or rough material, jean being the material most used. The process is very laborious, as it requires all the pressure that can be employed, and that, too, for some considerable time. It is part of the polishing. When the surface has been made level by this, the next thing is to go through the same again; but this time, instead of using powder as the cutting material, black or soft rotten-stone must be employed, with flannel or cloth kept well wetted. This makes the surface exceedingly smooth, and ready to be brightened up into a fine polish by rubbing the hand up and down. The workman so employed has to keep rubbing the dry hand into powdered white rotten-stone, also occasionally moistening the hand by placing it on a wet cloth for the purpose. The polish soon comes up under a practical hand. It takes practice in this polishing before the best work can be done. The work now passes to the ornamenter. After he has put on his ornaments of gold and colour, it is placed in a stove at only a few degrees of heat, as much heat would destroy his work. When dry, that part only of the article which is covered with ornament receives a coat of copal polishing varnish. This varnish does not improve the appearance, but is necessary to preserve the decoration. No polish or varnish can equal black varnish, which is about a fourth the price of copal. The varnish is put on with a flat camel-hair brush, and will harden in a heat of about 100° F. in 4 hours. If put in too great a heat it will turn colour and completely spoil the work. It is now ready for "finish" polishing, which consists of the rotten-stone process again and hand rubbing as before, and last of all, a few drops of oil are used with a sprinkling of water, and this is called oiling off. It requires dexterity, or, instead of adding to the lustre with the oil, it will completely dull the surface.

There are plenty of goods that do not go through all these processes, such, for instance, as grocers' canisters and numerous other articles. These, as soon as they have received the second coat of black varnish, are taken directly to the ornamenter without being "roughed" or polished, and if the varnish has been put on well and kept free from dust, they look very well. When no polishing is done either before or after the ornamenting, the article is frequently covered all over with the copal varnish coat. The only safe way of obtaining the proper varnishes is to get them from those who supply japanners.

When tin goods are to be japanned the only preparation necessary is to clean off all grease spots with a piece of clean rag dipped in turpentine; and as to heat, when it is not too hot to disturb the solder, it will not hurt the black varnish, providing it is put on sparingly. If not the varnish will shrivel. The finish upon grocers' canisters may be readily obtained, as there is nothing on them but good stoving and varnishing—no polishing.

Japanning and Bronzing Iron Frames of Pianos.—With common pianos the frames are not japanned, but with fairly good instruments the iron surface which is given a gold colour is japanned, while in high-class goods the work is as carefully finished as the best done in other branches of the trade. The first process is to prime the surface, which is done with a mixture of copal varnish with zinc white. About three coats are necessary, the first two being smoothed down with fine glass paper, the last with pumice powder and water. When the surface is quite smooth, the surface is given a coat of gold bronze powder, then varnished. The work is then stoved and given another coat of varnish and stoved again as many times as the quality of the work warrants. In best work six coats are given, each one, except the last, being rubbed down as already explained. The surface so obtained is considered sufficient finish, though parts which are particularly exposed to view (with horizontal grand pianos in particular) a final polishing with rotten stone and chamois leather is given.

Trays, Dish Covers, etc.—Well cleanse the covers from grease by washing in sulphuric acid and water. Rinse in cold water until quite free from acid. Purchase any quantity, say 1 pint, black, brown, yellow, or red japan varnish; pour a small quantity of varnish in a cup. Place the cover in a warm oven until quite hot; remove from the oven, varnish the cover in one direction, using a camel-hair brush. When every part required to be varnished is done, place the cover in the oven for 2 or 3 hours. If the article to be varnished is too large for the oven, it should be made quite hot in front of the fire, and same after varnishing, but care must be taken not to allow it to blister, and to keep free from dust and draughts of cold air.

Japanning Wood-work. (*See also* LACQUERING WOOD.)—The work to be japanned is first thoroughly cleansed and dried. If of wood, or any porous material, it is given, after being warmed, several coats of wood filler. This is usually whiting, or ivory black, mixed with rather thin glue size, and when it has hardened it is rubbed down smooth with pumice stone. It is then ready for the japan grounds. After the application of a ground colour the upper or polishing coats of varnish are applied. When this surface is heated for some time to a temperature of 250° to 300° F. (121° to 149° C.), it is found that the whole of the solvent or vehicle of the gums or resins in the varnish is soon driven off, and the gummy residue becomes liquefied or semi-liquefied, in which state it adapts itself to all inequalities, and when the coating is thick enough presents a uniform glossy surface, which it retains on cooling. This process of drying out and fusion secures a firm contact and adhesion of the gums or resins to the surface of the substance varnished, and greatly increases the density of the coating, which enables it to resist wear and retain its gloss longer. This process of hardening and finishing varnished or lacquered work by the aid of heat constitutes the chief feature of the japanner's art.

This method of japanning woodwork may be said to be that practised for comparatively common commercial wants, while the strictly ornamental branch of decorating wood by this means comes under the heading of LACQUERING. This is due to the influx of Japanese and Chinese work, and which is known as Lacquer Ware. This branch of the subject is dealt with fully under LACQUERING.

Colours and Grounds. *Common Black Japan Ground.*—Asphaltum, 1 lb. ; balsam of copaiba, 1 lb. ; oil of turpentine, q.s. Melt the asphaltum over a fire, and having previously heated the balsam, mix that with the asphaltum ; then remove the vessel from the fire, and put in sufficient turpentine.

Ordinary Black Japan Ground.—Mix shellac varnish with either ivory-black or lampblack, but the former is preferable. These may be always laid on with the shellac varnish, and have their upper or polishing coats of common seedlac varnish.

Superior Black Japan Ground.—Amber, 12 oz. ; asphaltum purified, 2 oz. ; boiled oil, ½ pint ; resin, 12 oz. ; oil of turpentine, 16 oz. Fuse the gum and resin and asphaltum, add the hot oil, stir well together, and when cooling add the turpentine.

Japan Black for Metals.—Umber, 12 oz. ; asphaltum, 2 oz. Fuse by heat, and add ½ pint boiled oil and 2 oz. resin ; remove from the fire and when cooling add 16 oz. oil of turpentine.

A Japan for Metals which can be Stoved at Low Temperature, about 80° F.—Dark Manilla gum, 18 oz. ; rosin, 3¼ lb. ; methylated spirit, 4 qt. As this is stoved at a low temperature aniline or coal-tar dyes may be used to give it any desired colour. These dyes are fugitive at higher temperatures. The japan requires stoving about half an hour only. It is somewhat transparent.

Transparent Japan.—Oil of turpentine, 8 oz. ; oil of lavender, 6 oz. ; camphor, 1 dr. ; bruised copal, 2 oz. Dissolve. This is used for japanning tin. Quick-drying copal varnish is customarily used in place of this.

Japan Flow for Tin.—Spirit of turpentine, 3 qt. ; balsam of tolu, 3 oz. ; linseed-oil, ¾ pint ; acetate of lead, 3 oz. ; balsam of fir, 3 oz. ; sandarach, 1½ lb. Put all these materials, except the turpentine, in a suitable vessel, place over a slow fire at first, then incorporate by stirring. Add the turpentine when the mixture has cooled to 80° F., or it may fire. This is transparent but may be coloured as follows :

Black.—Asphaltum, 4 oz. ; prussian blue, 1 oz. ; spirits of turpentine, 1 pint. Melt the asphaltum in the turpentine, work up the blue with it, then strain. This is sufficient for one quart of the flow described above.

Blue.—Indigo and prussian blue, each 1 oz. ; spirits of turpentine, 1 qt. Mix well and strain. Add of this to one quart of the flow.

Red.—Take spirits of turpentine, 1 pint ; add cochineal, 1 oz. ; let it stand 15 hours, and strain. Add of this to the flow to suit the requirement.

Yellow.—Take 2 oz. of pulverised root of curcuma and stir it into 1 qt. of the flow until the colour suits, let it stand a few hours, and strain.

Green.—Mix the blue and yellow together, then mix them with the flow until it suits.

Orange.—Mix a little of the red with more of the yellow.

Pink.—Mix a little of the blue to more of the red.

Inflexible Black Japan for Leather.—Shellac, 4 oz. ; wood naphtha, 16 oz. ; lampblack to colour. Dissolve by allowing to stand for some time in tank or bottle.

Flexible Black Japan for Leather.—Burnt umber, 4 oz. ; true asphaltum, 2 oz. ; boiled oil, 2 qt. Dissolve the asphaltum by heat in a little of the oil, add the burnt umber ground up in oil, and the remainder of the oil ; mix, cool, and thin with turpentine. This composition is very flexible.

A White Japan Ground is prepared from copal varnish and zinc white or starch. To form a hard perfect white ground is no easy matter, as the substances which are generally used to make the japan hard have a tendency, by a number of coats, to look or become dull in brightness. One white ground consists of the following composition: Flake white of lead is washed over and ground up with one-sixth of its weight of starch, then dried, and mixed with the finest gum, ground up in parts of 1 oz. gum to ½ oz. of rectified turpentine, mixed, and ground thoroughly together. This is to be finely laid on the article to be japanned, dried, and then varnished with 5 or 6 coats of the following: 2 oz. of the finest seedlac to 3 oz. of gum anime, reduced to a fine powder, and dissolved in 1 qt. of alcohol. The lac must be carefully picked. For a softer varnish than this, a little turpentine should be added, and less of the gum. A very good varnish, and not brittle, may be made by dissolving gum anime in nut oil, by boiling it.

The Tortoiseshell Japan.—This kind of japan is very pretty, and comparatively easy to manufacture. The work is first coated with a japan made by boiling 2 pints linseed-oil, to which 4 oz. of water have been added, till it becomes thickened; the mixture is then strained and further boiled, till it becomes of a pitchy consistency. This is mixed with turpentine to a workable substance, and then applied. On a thoroughly dry coating of this japan lay a number of vermilion spots to represent the clear portion of the shell. The vermilion japan is made by adding vermilion to shellac varnish; it should be laid on thinly and dried. The whole surface is then finally coated with a thin layer of the above described brown japan, still further diluted with turpentine. A course of stoving will be necessary, to thoroughly harden the japan.

Japanner's Gold Size.—Prepare a sufficiently large vessel and first boil in it half a gallon of linseed-oil for about two hours. Then gradually sift in 5 oz. dry red-lead, 5 oz. litharge, 5 oz. copper sulphate, stirring well. When the boiling has proceeded another hour add 1 lb. of gum anime previously melted and mixed with 2 pints of hot plain oil. Now heat and stir for about 5 hours, or until it hangs in strings from the ladle yet drops in lumps. Let all cool down somewhat, then mix in 6 quarts of oil of turpentine (the oil must not be too hot, nor must this be done too near the fire, or it may flash). This completes the process. If carefully prepared, it improves with keeping. It dries in about 15 minutes.

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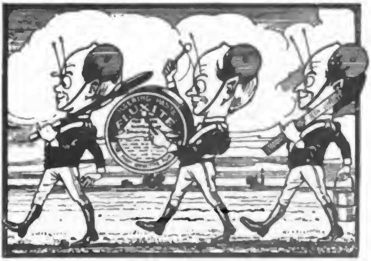

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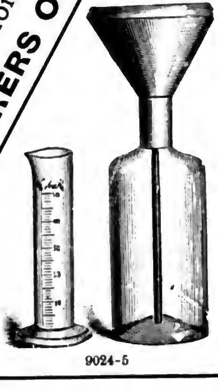

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